The AMSAT Journal

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July 1991

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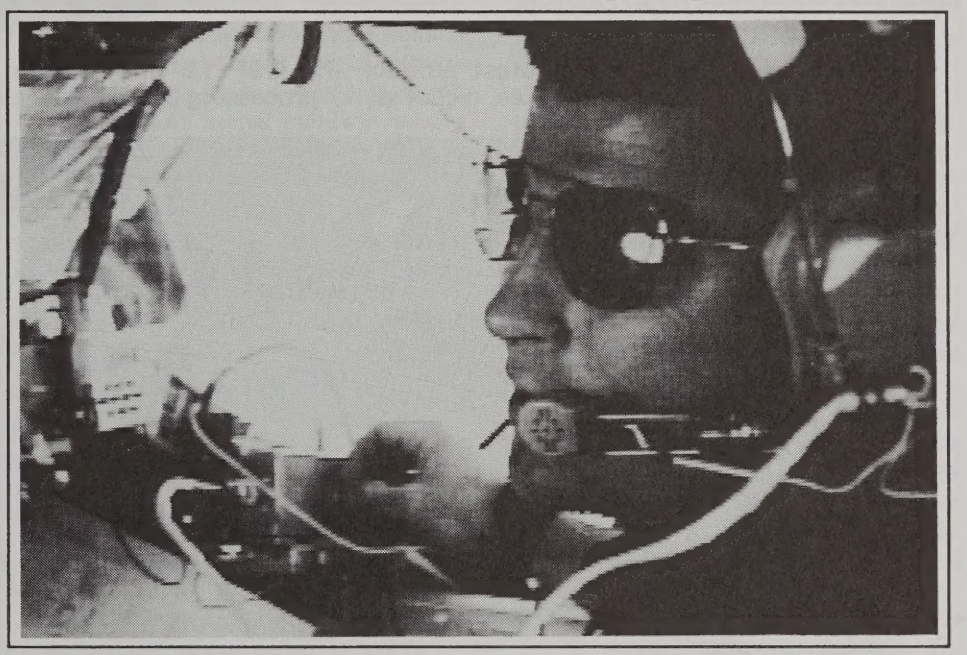

Shuttle Pilot Ken Cameron, KB5AWP, captured on Shuttle video during a QSO with one of the school QSOs. (NASA photo)

By Bill Tynan, W3XO
AMSAT VP of Manned Space Programs
c/o AMSAT HQ

With the launch of the Shuttle *Atlantis* last April, five licensed Radio Amateurs (the entire crew) were off on another Shuttle mission on which NASA had authorized Amateur Radio operation. The roster reads like a mini-hamfest: Mission Commander Steve Nagel, N5RAW, Pilot Ken Cameron, KB5AWP, Mission Specialists Linda Godwin, N5RAX, Jay Apt, N5QWL, and Jerry Ross, N5SCW. The primary purpose of the STS-37 mission was to deploy the Gamma Ray Observatory (GRO) spacecraft and conduct extra vehicular activities (EVAs) aimed at developing techniques for building the Space Station. It turned out that two EVAs were necessary when the boom supporting the high-gain antenna on GRO refused to deploy. Once again, the value of having humans along on space

(Continued on page 4)

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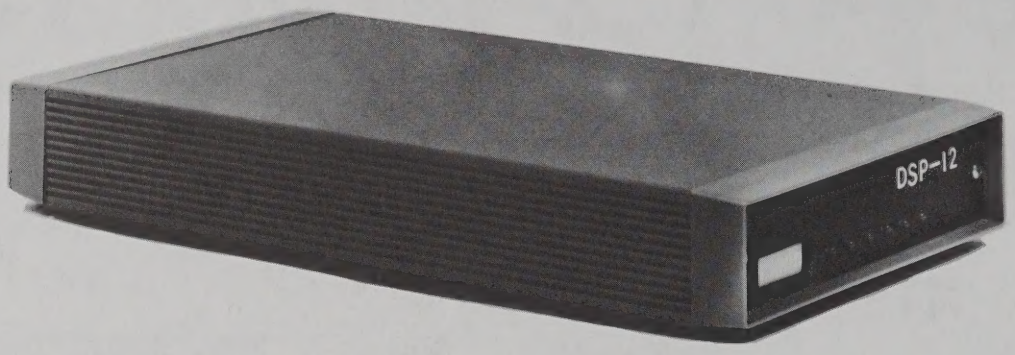

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It's Time to Return the Favor

By Drew Deskur, KA1M, *Editor in Chief*

The AMSAT Journal is a forum for AMSAT members interested in the Amateur Space Program to share ideas. It is a place where you can learn about an aspect of the hobby that perhaps you were otherwise not familiar with. As you have become more proficient in satellite operation, no doubt you got help from others who either showed you how to do something or pointed out where to get further information. Perhaps part of your current satellite station came from an article here in *The AMSAT Journal*. Now is the time to return the favor and help others.

The AMSAT Journal is always looking for people to submit articles on any aspect of Amateur space communication. *The AMSAT Journal* is striving to be a balanced publication. We are interested in publishing a wide spectrum of articles: from the deeply technical (like The Shape of Bits to Come) to do-it-yourself technical articles (like the 435 Yagi article) to operating aids like a low cost relay sequencer. Articles don't have to be technical in nature. Your experience with remote satellite operation — or pictures of your Hamfest AMSAT Display are welcomed. I would like to start a new section similar to *QST's* Hints and Kinks. It would be primarily focused on helpful ideas that perhaps are not large enough to be a full fledged article. The point here is to provide a little something for everyone.

However, we can't print your idea or project or Hamfest picture if you keep it to yourself. Got something in your shack that you think is a neat solution to a problem you once had — write it up and submit it. If at all possible the text should be submitted in electronic form. The Editorial Staff of *The AMSAT Journal* uses Apple MACINTOSH and IBM compatible PCs. Submissions on disk should be in a plain ASCII text file format and preferably on 3-1/2" diskettes (spell-checking is appreciated). Pictures and drawings are strongly encouraged. Clean, clear drawings are essential and it helps if pictures which are included are in focus and properly exposed. If you have trouble picking out the antenna elements in a picture — you can be sure that the rest of us will have problems also. Captions should be included with each picture, including names and call signs of those in the picture.

As much as we would like to print everyone's article or Hamfest picture, we must consider the suitability of the content of each article along with space available in each *AMSAT Journal* so that not every article submitted will be printed. Very few of the authors published in *The AMSAT Journal* are "professional writers" so don't feel that you don't have what it takes to submit an article. Put together a piece that excites you and most likely it will excite others. Here is your opportunity, as Andy Warhol put it "... to be famous — for at least 15 minutes". *The AMSAT Journal* is what you make it. It can help you return the favor. ■

Take Note: Pirates Are Stealing Big Bucks From Your Satellite Program!

By Doug Loughmiller, KO5I
President, AMSAT-NA

From time to time reports have filtered into AMSAT Headquarters concerning the unauthorized distribution of AMSAT tracking software such as InstantTrack and Quiktrak by firms and/or individuals who are ignoring the copyright of the authors involved and who are selling copies of software which AMSAT retains the rights to for their own financial gain. Whenever we learn of copyright abuses, steps are taken to contact the violators involved and an attempt is made to resolve the problem. Unfortunately, many times the information that reaches Headquarters is incomplete and thus we are unable to respond in any meaningful way to the given infringement. Over recent weeks we have seen a marked increase in the number of reports of software pirating. This is of a major concern to us as this represents a serious threat to the financial well being of our organization.

As most AMSAT members are aware, donations generated by the distribution of AMSAT tracking software account for a large percentage of the total number of dollars which are available for AMSAT to use in the furtherance of our programs and projects, particularly the construction of the OSCAR satellites.

YOUR HELP is needed! In order to fight this problem, it is important that AMSAT Headquarters be made aware of each individual case of infringement. Further, in order to mount an effective defense of our copyrights we must have a total

(Continued on page 29)

Elementary students (left to right) Stacey Brandt, Roy Loudermilk, Kyle Humphries and Robert Ralford have a not-so private QSO with Ken Cameron and Steve Nagel. (NASA photo)

STS-37 Review: First Flying Hamfest

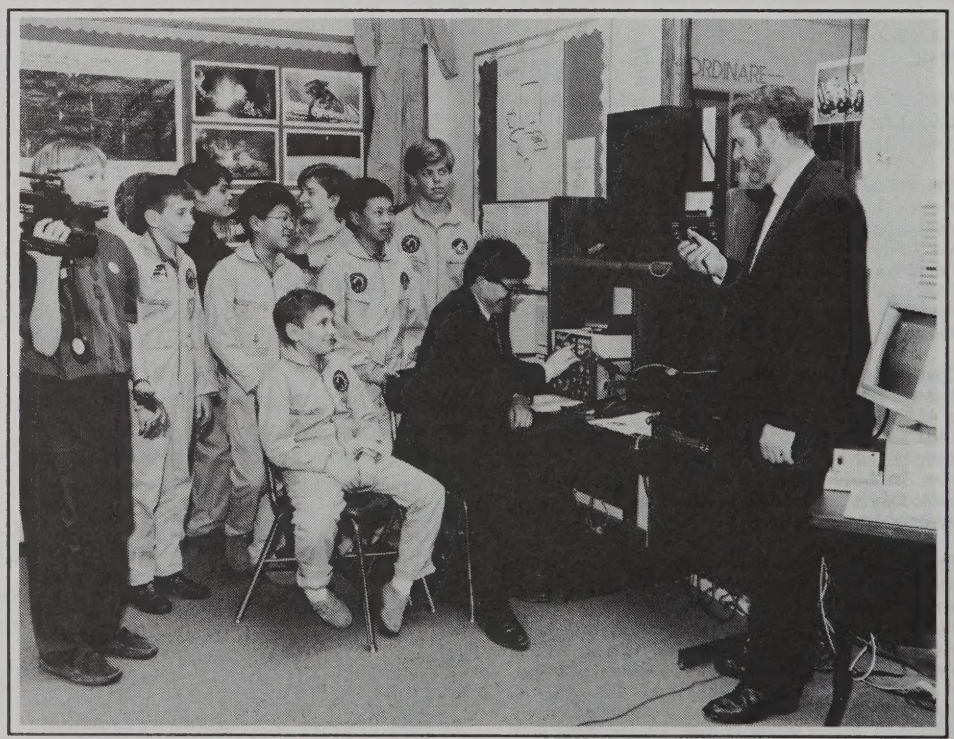
(from page 1)

missions, to fix things when they don't go as planned, was demonstrated.

But, we Hams were particularly interested in what else the STS-37 astronauts accomplished operating the Shuttle Amateur Radio Experiment (SAREX) equipment. Like STS-35, with WA4SIR aboard, the primary thrust of SAREX operation on STS-37 was to link the Shuttle crew and school children. However, unlike the SAREX installation on STS-35, this one had the fullest capability so far, built into the equipment. As you may recall, severe space limitations on STS-35 required a cut back in the amount of Amateur gear that could be taken aboard. This limited STS-35 to voice and packet operation. It turned out that some limitations befell the STS-37 SAREX equipment too — but more on that later. For STS-37, the SAREX equipment suite was designed to be capable of two-way voice communication using 2 meter FM, two-way slow scan TV (SSTV) also using 2 meter FM, packet using AFSK on 2 meter FM and, for the first time ever, fast scan television (FSTV), uplink only, using AM on 70 cm.

Like all Shuttle missions on which Amateur Radio has been aboard, Ham operation had to take second priority when it came to other scheduled crew activities. However, the fact that five licensed Amateurs were aboard facilitated scheduling Amateur operations somewhat. That was the good news. The bad news was that STS-37 was a relatively short mission (five days versus ten days scheduled for STS-35). The other negative was that, unlike most Shuttle missions, the highest intensity of workload occurred late in the timeline rather than early. Since getting accustomed to the space environment generally requires a day or so, it was not known whether Amateur Radio operation during the first day would be possible. It turned out that it was. However, another situation presented itself which restricted SAREX operating time. That was the unscheduled EVA to free-up the antenna boom on GRO.

Despite these limitations, Amateur Radio realized a great deal of benefit from SAREX operation on STS-37. As on STS-51F and STS-35, emphasis was placed on communicating with young people. As on STS-35, a system of relays through designated Amateur stations, in conjunction with a telephone bridge, was employed to obtain the greatest coverage — both in terms of length of the communication sessions and number of students that could participate. But, unlike STS-35, the STS-37 timeline called for the Shuttle to be over the U.S. during the daylight hours; so relay stations in this country could be used in place of the Australian stations which helped out during STS-35. A network of three stations located across the



Waiting for AOS of STS-37. (NASA photo)

southern tier of states was established. The West Coast station was Ralph Warner, N6MNN, Holtville, CA. In south Texas it was Bob Douglas, W5GEL, Corpus Christie and, on the East Coast, Don Carlson, W4RDI, Fort Myers, FL. Additional schedules were supported by using South American stations: PY2BJO and HC5K. Also, a number of schools in Australia were linked up with the Shuttle crew using direct contacts through Amateur stations set up at the schools in the various states of the country. This activity was coordinated by Graham Ratcliff, VK5AGR — one of the relay stations participating in the STS-35 mission.

The slow scan television system was to have been used both with individual stations as well as with stations set up at schools. Despite the fact that the capability existed for two-way SSTV, emphasis was placed on one-way transmissions from the Shuttle to ground stations. There were two reasons for this. First, it was felt that young people would be more interested in pictures sent to them from space in essentially real time, rather than sending their pictures up. In addition, many one-way (listen only) sites were involved. It was hoped that students at these sites would be able to see the SSTV space pictures along with those who were at sites selected for two-way participation. It is a fortunate thing that emphasis was placed on downlinking of slow scan pictures, as the SSTV uplink capability was one of the parts of the experiment that did not work. In addition, SSTV pictures sent from space and relayed through the telephone circuit turned out to be less than satisfactory. Some good slow scan pictures were received directly however. I saw some captured at W5RRR, the station of the JSC Amateur Radio Club, which were quite good.

The packet robot system, first tried on STS-35, was part of the equipment again — with some adjustments in an attempt to maximize the number of successful QSOs. We all had high hopes for this part of the SAREX operation on STS-37, since it was known in advance that the short five day mission would not allow much time for general Hamming via voice or SSTV. However, the packet system was supposed to fill the gap and provide many contacts with ground based Amateurs. Unfortunately, a hardware failure in the SAREX equipment prevented packet from functioning. This same hardware failure caused lack of ability to uplink SSTV. After the flight, Lou McFadin, W5DID, found that the culprit was a simple broken wire at a connector. This occurred, despite all the testing the equipment had received and the fact that the same cable performed fine on STS-35.

Linda Godwin, N5RAX, on the Flight Deck of STS-37. (NASA photo)

As previously stated, the 70 cm fast scan television experiment carried on STS-37 was strictly an uplink-only proposition. Those who ask why it could not be two-way — with ATV transmitted from the Shuttle, need to look at the link budget associated with the transmission of FSTV. Even if SAREX could be allocated the volume and weight necessary for a high power ATV transmitter, the amount of Shuttle power available to us is far below that required to provide usable downlink fast scan TV pictures. Even for uplink only, very high effective radiated power is required in order to achieve recognizable television pictures at the Shuttle. Therefore, a few selected stations were assembled to try to achieve a successful demonstration of the feasibility, and value, of having TV reception available on manned spacecraft. It is believed that this is the first time that an attempt has been made to send standard TV to a manned spacecraft by either the U.S. or the Soviets.

In spite of the difficulties inherent, the FSTV experiment on STS-37 was a great success. Stations known to have been successful were KC6A, Long Beach, CA, N9AB near Chicago and WA3NAN, using 1 kW to a 30 foot dish at the Naval Academy at Annapolis, MD. All of these stations succeeded in getting recognizable pictures up to the Shuttle. Other stations selected to try had marginal or negative success. Amateur Radio has scored a first with this one — a feat for which we can all be proud. Particularly proud is Andy Bachlor, N9AB, who, with the Schaunberg, IL Motorola Amateur

A student at the University School, Shaker Heights, OH getting a chance to talk to Ken Cameron, KA5AWP, aboard the Shuttle *Atlantis*. (NASA photo)

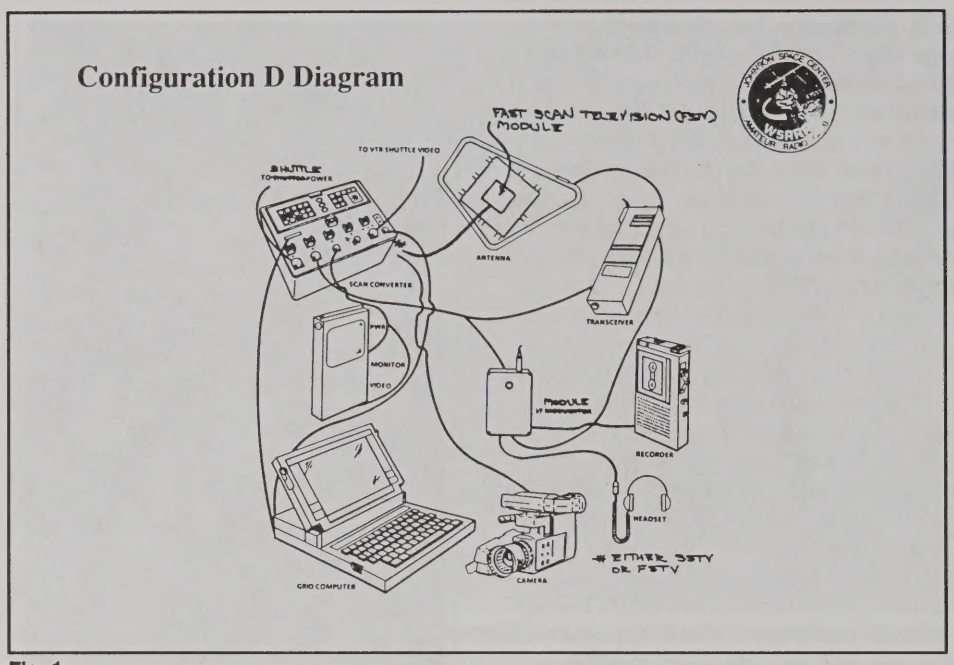


Fig. 1

Radio Club built the TV module which became part of SAREX and designed and constructed the new dual band window antenna, shown in Figure 1.

Frequency Plan

The frequency plan shown in the article "The Term Hams in Space Takes on a New Meaning" which appeared in *The AMSAT Journal* for March 1991 was used for Amateur Radio operations on STS-37. The primary voice uplink frequency was 144.95 MHz while the corresponding downlink was 145.55 MHz. This is in line with the policy of having Earth stations use a different frequency than that used by the Shuttle station and, at the same time, maximizing the number of people who can manage split frequency operation by employing the same offset as repeaters do. As for all Amateur Shuttle missions, stations were asked to transmit only at times the spacecraft was approaching their location, preferably only when the downlink had been heard. This is important because SAREX may be a different frequency than previously planned. Such a change could be necessitated by a last minute change in plans such as setting up an additional school schedule to take the place of one which was not wholly successful. Calling "blind", which was particularly evident during STS-35, merely caused QRM to terrestrial users of the frequencies involved. From what we can determine, there were far fewer instances of such interference to terrestrial users during STS-37 than during STS-35.

As always, the best way to know the location of the Shuttle is through the use of a tracking program run on a personal computer. Besides, it's fun and educational to see where the astronauts are at any given moment. AMSAT has available programs for most popular computers, which will be valuable for future Shuttle Amateur missions. Call AMSAT Headquarters at 1-301-589-6062 for information on the various tracking programs available.

Despite the shortness of the mission and the unscheduled EVA and the hardware failure which prevented packet from working and blocked reception of SSTV uplink signals, the SAREX portion of STS-37 was very successful in achieving its major objective — bringing school children into direct contact with Shuttle astronauts. Two-way conversations were conducted with U.S. school children at the locations shown in Table 1. Fig. 2 shows the networking required on the Earth side of one such contact. Once again the Darome Connection came through with flying colors providing the telephone bridge between the U.S. and South American relay stations to the participating Amateur groups around the country. Fig. 2 also shows a diagram of how this network was set up. In addition to the schools and other educational institutions in the U.S., a number of schools in Australia were brought into contact with the Shuttle by various VK

Table 1 — Two-way School Participants on STS-37

Robert E. Morgan, K8RBV	University School, Shaker Heights, OH
Roberta Feldman	Reizenstein Middle, Pittsburgh, PA
Terrence R. Redding, WB5LMJ	Southwest Oklahoma Schools
Terry R. Brandhorst	Clear Creek Ind. School District, League City, TX
Joe Laughlin	Lyman High Sch., Longwood, FL
Mike O'Brien, N9JEL	Discovery Center Museum, Rockford, IL
Philomen Leonelli, WF6L	Potter Jr. H.S., Fallbrook, CA
Tom Daniels, N3CXP	Hanover Ele., Bethlehem, PA
Larry Calvert, WA9OAO	Monroe Central School, Parker City, IN
George Robinson, WA3LVO	Beaver Creek Ele., Dowingtown, PA

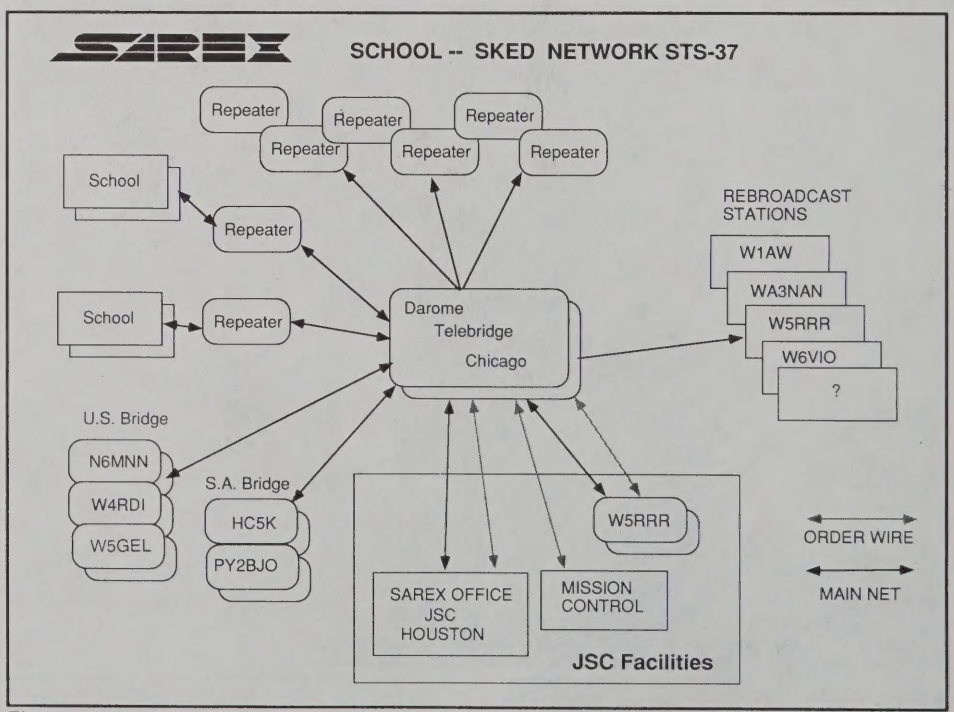


Fig. 2.

Amateurs setting up equipment at the schools. Those known to have taken part include VK5AGR, VK6KAE, VK3APP, VK6PT, VK3YXK, VK2EMU, VK3CFI and VK3JON.

Future Plans

Although it is too soon to be precise, we may see more Hams on Space Shuttle missions as early as this Fall and/or next Spring. AMSAT and ARRL have sent a joint letter to NASA requesting that SAREX be included on a high inclination mission. This would considerably increase the number of Amateurs throughout the world who could have a chance for a direct contact. One of the objectives the SAREX Committee has established for itself is to try to accomplish something new and different on each flight. This may involve revised operational plans or it may require different equipment to be flown. However, it is not easy to get new equipment aboard. Anything that has not already been certified must go through a rigorous series of tests and analyses to prove that it does not present a safety hazard and is compatible with other Shuttle equipment and systems. This entails a considerable amount of work by people who are already overburdened.

Steve Nagel, N5RAW, seems to be enjoying a not-so-leisurely QSO. (NASA photo)

Nevertheless, the SAREX Committee would appreciate hearing suggestions for future "Hams-in-Space" experiments. One, which I am particularly interested in seeing happen is the use of SSB. But, this requires a new transceiver — with all of the problems already mentioned. Write me at AMSAT Hq. with any suggestions you have. ■

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AMSAT-NA Operations Report

In this month's column I'll talk about three topics: microwave techniques, station automation, and the PACSAT marketplace. Also, notice that there is a review of Marty Davidoff's Satellite Experimenter's Handbook, 2nd Edition *which appears elsewhere in this* AMSAT Journal. *Look for it, but if you don't have time to read it, the advice is: "You need a copy of the 2nd Edition."*

By Courtney Duncan, N5BF
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Microwave Techniques

Several years ago, I worked for KXTX Channel 39 in Dallas, Texas. I started out as an engineer at their transmitter site in Cedar Hill. The TV carrier final amplifier at the time was a pair of water-cooled Klystrons that fed several tens of kilowatts at 626 MHz into 6-1/2 inch air-dielectric copper "coax" which ran 1500 feet up a tower to the transmitting antenna array. The klystrons were about the size of a washing machine, twice as high and large enough so that to service or replace one, after disconnecting the electricity and the plumbing, it was necessary to wheel it out of its compartment on rollers.

During those long days when I became bored with watching the TV (when things worked right there wasn't much to do and when they didn't there wasn't enough time to do what was required) I would fantasize about using the same approach on 80 meters, to scale. The final amplifiers would be about the size of downtown Dallas, and the feedline like a major freeway. Ridiculous and fantastic as this sounds, it's not much different from what Hams sometimes do when they attempt to use "HF thinking" at UHF and above.

When one goes to set up an HF station, the standard approach is to start with a transceiver, a transmitter and receiver in a single box that has internal antenna switching. Run coax from this to an antenna somewhere outside which consists of a wire, dipole, or yagi with a half dozen or fewer elements. This approach is completely reasonable at HF. There is no need for ultra low noise electronics since atmospheric QRN usually sets the noise floor relatively high. There is no need to consider transmitters and receivers separately or RF to IF to AF arrangements; inexpensive coax switches have acceptable losses and all of the details of conversion from RF to AF are handled inside the box. Life is pretty simple.

As frequencies go higher and performance requirements vary, an HF station-like approach goes from inefficient, to marginally useful, to absurd.

For example, say you wanted to set up a station for 1296 MHz. (I realize that satellite Mode L uses 1269 and requires a ground transmitter only, we'll come back to that simplification later.) First you might obtain a transceiver for the band. You would notice right off that it costs more and puts out less power than similar transceivers for lower frequencies. This is partly because in the current technology, it is more expensive to generate power at higher frequencies, which is unavoidable. It is also partly because cabling and switching are starting to get expensive in the GHz range, and this IS avoidable, as we will see below. Now, you've got the transceiver on your desk, it's time for feedline and antennas. You notice that feedline loss is going to be a problem at 1.2-1.3 GHz, so you decide to use some high quality, low loss (read: high cost) feedline and connectors. Signal lost in the feedline is lost for good, so, after some experimenting you decide to mount a receiving preamp and transmitting final amplifier near the antenna. This too is costly and troublesome, the preamp and amp have to be switched, mandating more expensive relays and more connectors.

By the time all this works, you are a lot poorer and probably not much happier. Some of the expense and trouble can be avoided, however, by taking a microwave approach rather than an HF approach to the setup.

The May 1991 *QST*, page 30, contains an excellent article on this subject: "A High-Performance UHF and Microwave System Primer" by Dave Mascaro,

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WA3JUF. In Figs 1 and 2 of the article, he compares and contrasts the "typical" approach versus a much less costly and more clever method for constructing a station for 3.4 GHz. The key simplification is that two separate antennas are used, one for transmit and one for receive. The receive antenna feeds the mast mounted preamp which drives the main feedline (which need not be as high quality or low loss because it comes after the low noise first stage). Then comes the converter and the 2 meter IF rig. The transverter feeds another inexpensive feedline that drives the mast mounted amplifier and the other antenna. No expensive microwave relays are needed and the number of connectors and the amount of expensive coax required is minimized. Of course it doesn't make sense to use dual feedlines and mount active components near an antenna for 3.5 MHz, but at 3.4 GHz, it is the best way to go and is much less bothersome than the typical HF approach.

I would take Mascaro's idea and extend it even further, moving the transverter itself out to the antenna. Then, the only signals that have to travel over the long coax from the shack are low level 2 meter IF signals. The quality and grade of coax and connectors required for this are much more appealing than a method that requires sending high level or low noise microwave signals long distances.

Indeed, if we could start from a blank sheet of paper to design such a station, we might decide to put all of the RF and microwave electronics at the antenna and just run audio and control signals back into the shack, in a "control-head-like" fashion. Then, the line from the shack to the antenna could be as simple as a 6 or 8 conductor rotator cable.

Now, in my own shack, I've been forced to use the HF approach (on 1296/1269 and most other satellite bands) by the appliances I've selected. Manufacturers apparently tend to think of equipment (either stand-alone radios or modules for multi-purpose rigs) as functional extensions to higher frequencies and don't seem to consider a 1.2 GHz or above station (as a whole) from a microwave engineering viewpoint. At these frequencies, it appears that signal margins could be improved by 5 dB and costs reduced by at least 3 dB by designing the whole system from microphone to antenna with techniques for the appropriate frequency in mind rather than just emulating HF transceivers and solving the problems of higher losses with money. When you're going to spend several hundred or a few thousand dollars for some new Amateur Radio capability, 5 dB signal and 3 dB$ are nothing to scoff at.

I don't know how much good it would do to talk to manufacturers about a fundamental change in system approach like this. They, after all, have to sell to a market of Amateurs who are comfortable with the HF station way of doing things and it might take lots of education to get customers to buy into a new approach at the point of sale. But, here is where the experimenters among us can take the lead and show the way. I encourage those of you who are putting in equipment, for Mode L uplink for example, using transverters or home brew rigs, to implement a setup that makes good engineering sense at the frequency in question and then tell us about your results by sending an article (with pictures) to *The AMSAT Journal*. Following the lead of WA3JUF and after a few success stories at AMSAT, perhaps others (maybe even the appliance makers themselves) will start to catch on.

Station Automation

Now that the three new PACSATs (UO-14, AO-16, and LO-19) have been in fairly stable operation for several months and most of the initial greetings between stations around the world have been made, many are beginning to think in terms of automating or semi-automating their stations so that they can send and receive their mail and act as relays (gateways) for traffic without having to stay up late every night and go in to work late every morning.

A worldwide group of traffic gateway stations coordinated by Dave Medley, KI6QE, is particularly active in discussing options and methods of standardization. This group is busy handling traffic manually right now and have developed procedures by doing so that they think should be automated. Problem areas still under investigation are:

Antennas. Some are reporting success with fixed antennas, but those using beams have better throughput and a lower connect-dropout rate. Beams require steering. The means for automatic, unattended control of beams is available off-the-shelf but is another expense in station setup and can lead to long term maintenance problems. Also, beams intended for satellite work are usually circularly polarized. The Microsat downlinks use circular polarization; they were designed this way so that simple, linear antennas could be used on the ground without polarization switching and with roughly uniform results. The sense or circularity changes as the satellite changes orientation in space, however. This has been studied and predictive models are complex to say the least. Circularly polarized antennas need to have switchable circularity sense and the switch needs to be driven by some foolproof sensor (S-meter) or algorithmic predictor. Neither appears to be trivial.

Frequency. Most 1200 baud PSK modems have the means to control receiver frequency through microphone stepping switches. Those using rigs with 100 Hz stepping report losing packets when a 100 Hz AFC step occurs during the time period when a packet is being sent or received. Other difficulties include problems with the AFC running off during fades and reacquiring lock on the wrong vestal sideband. These problems can be handled easily by a present operator, but can cause significant amounts of data or whole passes to be lost in fully unattended service. UO-14 9600 baud modems have no such tracking feedback and so receivers must be tuned open loop or manually. The main frequency problem is knowing what frequency to start a pass on and getting the radio on that frequency at the right time. At Weber State University, WA3PSD reports about 50% success with just leaving the radio tuned to a frequency that has been seen before at the start of similar passes. This can work a maximum of once between visits from an operator. Hardware for computer (tracking program) based frequency control of many radios, and even some semi-automatic software solutions (such as the one provided by the Kansas City Tuner) are available off the shelf, but this is a tricky problem nevertheless and one requiring more work before a suitable, general solution is found.

Software. The public domain, PC based, ground software for PACSAT access is automatic once operations are initiated by operator keystrokes, but an operator is required to be present during the pass to type those keystrokes at just the right time. The specifications for the protocol are also public and anyone who wishes is encouraged to write their own ground software. No completed versions of homebrew software have yet been offered, at least widely. The designers of the protocol and authors of the public domain software are responsive to the input from the gateway stations and KI6QE has actually started work on a specification of extensions to the software that would make semi-automated gateways possible. There will certainly be upgrades to this software as time permits (read "someday"). Rather than waiting for AMSAT (which only has two full time employees, neither of whom are computer programmers and two PACSAT ground software programmers, neither of whom are employees) to do all of this, here is an opportunity for several

people to make important contributions from information already available. I would like to see at least one volunteer write up a generic, no frills, functionally segregated version of the PACSAT protocol and publish the source code in *The AMSAT Journal* for reference purposes, similar to the way that BASIC ORBITS by W3IWI was published in *Orbit Magazine* #6 over ten years ago. This would not necessarily be a definitive, fast, compact, full featured, or ultimate version of the protocol, but would be a version that was known to work on some machine and that could be used for reference by others designing PACSAT ground stations for gateways and other as yet unthought of applications.

Methodology. Clearly, there is much yet to be done on the PACSAT automation front and now is the time to be involved in foundational work along these lines. The most effective method of development that I've observed with this group is to set up and do whatever is needed manually first, then figure out what parts of the manual process can be automated easily. This is much more efficient than sitting around thinking about what needs to be done and what issues need to be addressed without gaining any real operational experience. And, in any case, the results are not always intuitive. For example, the problem of automatically figuring out when to throw the circularity switch on a downlink (or uplink) antenna is non-trivial, though it is trivial to do the task and evaluate the results when operating manually. The problem of steering beam antennas automatically, is, on the other hand quite simple to solve (using available hardware), though it might not seem so on first consideration.

I'll be very interested in seeing what the gateway automation working group comes up with and hope to actually contribute a snippet here and there myself as time and opportunity allows.

The PACSAT User Base

Although it can probably be argued that many of the elite in Amateur Radio are found on the satellites due to the tenacity and competence required to achieve regular communications in our experimental corner of the hobby, the following list demonstrates that it is not only the elite of Amateur satellite operators who are on the packet satellites but rather a new and different crowd of highly skilled Amateurs. The following are the call signs that appeared in the AO-16 activity log from February through April 1991, a period when activity was just beginning to build up. Thanks to Paul, KB5MU, for extracting this data from the logs. There are 275 calls in the list. Look for your friends and if your call is not here, isn't it time you started thinking about what fun you are missing?

9H1EY	AB4KN	AB4PX	CE3XK	DD1E	DD4YR	DF5DP
DG8FBL	DJØUN	DL1SBY	DL1YDD	DL3DA	DL6KG	DL7AOT
DL8NCI	DU1POL	EA2ARU	EA2CLS	EA3DXR	EA4QV	EA6IC
EA8RT	EB3CDC	EI6EH	FO5LQ	GØ/K8KA	GØORX	G1BYS
G1JAR	G3CDK	G3KMI	G3PJA	G4AXC	G4ULS	G4WFQ
G8ISI	G8TPF	G8TZJ	GU6EFB	HA4EHQ	HA5BME	HB9AQZ
HB9BOM	HB9CQK	HB9SKA	HB9XJ	HC2FG	HG4EHQ	IØJX
IØLYL	I2KBD	I3RUF	I4UOT	I6CGE	I6JZH	I7DFV
I7SKW	IK4IDY	IK6AWA	IKØHIT	IKØOEK	IT9DLN	IT9UJY
IV3IBX	IV3TKI	IW1BMJ	IW2CTJ	IW2DMN	IW3QPC	IW5BT
IW6MMY	IW9BJU	IWØBFC	IWØBNO	IWØCNB	JA1OGZ	JA1QHQ
JA6AQV	JA6FTL	JH1LVN	JH1QQN	JH1TWZ	JR1EDE	K2VEE
K4BQH	K4EVH	K5QXJ	K6OYY	K8IRC	K8RSP	K8TL
K8YAH	KA1IU	KA2MOV	KA9LNV	KA9QPG	KB3KJ	KB5MU
KB7CNN	KB8KTC	KB9CML	KC4EBR	KC4SA	KC4UZA	KC8LC
KC8WF	KD2CQ	KD6UY	KD8SI	KD9QB	KEØVZ	KE5ZW
KE7GH	KE7KD	KE7NR	KF4WQ	KF6OQ	KF7KN	KG4TM
KG5OA	KG6EX	KH6GMP	KI6QE	KJ1X	KM4XH	KZ1B
LA5DI	LA6GH	LU1CGB	LU1ESY	LU1EXC	LU1FYZ	LU1NET
LU1OGG	LU2BDT	LU2EXS	LU3XAL	LU4AEY	LU4ENQ	LU6DWA
LU6DYD	LU7ABF	LU7DSU	LU7HP	LU7NN	LU7XAC	LU8DYF
LU8EMH	NØJAR	NØJVH	NØKKZ	N1CHM	N3CXP	N4HY
N4IFD	N4PLY	N4TPY	N5AHD	N5BF	N5ITU	N6KK
N6LYT	N8AM	N8DNX	N8EMR	N8ENX	N8ITP	N9CLX
ND1V	NH6WE	NK6K	NL7NC	NMØH	NU6X	NU9
NZ3F	OH1KH	OH2MBM	OH2NRG	OH2SN	ON4KVI	ON5PV
ON6JC	ON6UG	ON6ZB	PA3DVG	SM5BVF	SMØGOS	SMØTER
SP5ALV	SP5GTI	SV3KH	SV8RV	VE1HD	VE3CDY	VE3NNW
VE6BJH	VE8DX	VK2AHB	VK2AIT	VK2BKQ	VK2XLG	VK3DTO
VK4CJO	VK5ACF	VK5AGR	VK5AKJ	VK5HI	VK5ZK	VK5ZTY
VK6BMD	VK6VV	VK7ZBX	VK7ZST	VP8ALJ	VS6VU	W2ICZ
W3GYJ	W3HH	W3TMZ	W5IU	W5RRR	W6SHP	W6TRW
W6XY	W7XS	W9FMW	WØSL	WA1GPO	WA1OBI	WA3PSD
WA4EJR	WA4NFY	WA4SCA	WA5NOM	WA5ZAF	WAØPTV	WB1HBU
WB4ULT	WB5AAA	WB5BZE	WB5DBF	WB5EKW	WB5RMG	WB5TKI
WB6HHV	WB6LLO	WB6UJD	WB7QKK	WB8NNJ	WB9ANQ	WBØDHH
WBØEZR	WBØNCR	WBØQJB	WBØSMX	WC8J	WD8KNL	WDØE
WH6AMX	WJ9F	YBØQC	YN1UNI	ZL1ACO	ZL1AOX	ZL1TDW
ZL1TJK	ZL1TRE	ZL1UNM	ZL1WN	ZL2AMD	ZL2TPO	ZL3AGL
ZS1ABM	ZS5NO					

The LO-19 logs have not been checked similarly, but due to the similarity of equipment needed, it is a fairly safe assumption that LO-19 users and AO-16 users are very nearly the same group.

The following list of 118 UO-14 users was compiled by JA6FTL as of about 23 May 91. There is some crossover between these calls and the 1200 baud PACSAT users, but not as much as you might expect.

CT1DIA	DB2OS	DD1EG	DF3LZ	DF5DP	DG3LV	DK2SM
DK2SN	DL1SBY	DL1YDD	DL4HBB	DL6KG	DL8NCI	EA2ARU
EA2CLS	EA4BPN	G2BFO	G3CDK	G3PJA	G3RUH	G3WGM
G3YJO	G4AXC	G4WFQ	G8NOB	G8TZJ	GØ/K8KA	GØMJW
GB4SFS	HB9AQZ	HB9BOM	HLØENJ	I2KBD	I3RUF	I6CGE
IØJX	IV3IBX	IW3QPC	IW3QUB	IWØCNB	JA1OGZ	JA1QHQ
JA6FTL	JH1TWZ	JL1WJZ	JN1ATB	JR1EDE	JR1ING	JR8XPV
K7PYK	K8IRC	K8YAH	KA2MOV	KC2PH	KF4WQ	LA6GH
LU8DYF	N1IJP	N3FKV	N4HY	N5AHD	N5BF	N6HBB
NK6K	OH1KH	OH2SN	OH2YU	OH6KG	ON4KVI	ON5PV
ON6UG	PA3DVG	PE1CHL	PE1DNA	PE1HML	RK3KP	SM5BVF
SMØTER	SV1IT	SV3KH	UA3CR	VE4XOR	VE6BJH	VK2AIT
VK2BKQ	VK2XLG	VK3CFI	VK3DFI	VK3DTO	VK3JAV	VK5AGR
VK5HI	VK6BMD	VK6VV	VK7YAO	VK7ZBX	VK7ZST	W2ICZ
W3GYJ	W3QNS	W7KRC	W9FMW	WA2LQQ	WA9FMQ	WAØPTV
WB6YMH	WB9ANQ	WB9MJN	WBØKSL	WC8J	WD3Q	WDØE
YN1UNI	ZL1AOX	ZL1TJK	ZL1TRE	ZL1WN	ZS5NO	

We don't have the analytical tools in place yet to list all of those additional stations that benefit directly from PACSAT message relays (like all of the nodes and users on AKNET, for example) and it may not be possible to more than estimate those who benefit indirectly through bulletin and information dissemination but we estimate that there are now several dozen such beneficiaries and we are now at just the beginning of the growth phase for the digital satellite service.

This increase in "Amateur market share" achieved by AMSAT through essentially a new product has been an organizational goal for at least a decade. It is good to see the momentum building. ■

A Call for Articles

Hey you! Yeah, the readers! Let's hear from you!

By Doug Howard, KG5OA
2517 Coldstream Drive
Fort Worth, Texas 76123

If I were to describe *The AMSAT Journal* (in 25 words or less), I would say it was a publication by, for, and about the Amateur Satellites USER. That's right, the USER! It is not the Editor's intent to solely document the technical and/or operational characteristics of the Amateur satellites themselves.

But rather, how the "ground bound" users of the satellites can best utilize these unique resources.

Given that we "users" of Amateur satellites are a talented group of individuals employing a specialized technique of Amateur Radio communications, it seems (not quite) obvious that the best source of relating information concerning these specialized communications techniques is, in fact, this publication we call *The AMSAT Journal*. It is our desire at AMSAT, to enable each and every Amateur satellite user to get the most enjoyment of the satellites (that we have labored so long and hard to provide) as is possible from one's station.

But where does *The AMSAT Journal* get all of this great information to provide to the users? The answer, of course, is the users themselves! No one user of the Amateur satellites could ever claim to know "all there is to know" of Amateur satellites. Thus, the sharing of knowledge becomes essential to maximizing the ability of all Amateur satellite users. And this is where YOU, the reader of this publication, come into play. Believe it or not, YOU are the best source of information for *The AMSAT Journal!*

A New Beginning

You may have noticed recently that there is a new Editor of *The AMSAT Journal*. He is Drew Deskur, KA1M. Drew is not a newcomer to Amateur satelliting. In fact, his father was K2ZRO, for which the "ZRO" test was named after. For those of you who don't know, receiver sensitivity and signal-to-noise ratio is the "name of the game" in Amateur satelliting. The ZRO test is the "standardized" method which we use to evaluate the receiving capability of the user station. So, I guess you could say that Drew grew up to be "sensitive" to the Amateur satellite community.

Doug Loughmiller, KO5I, President and General Manager of AMSAT-NA, has asked Drew Deskur to be Editor of *The AMSAT Journal*. And in doing so, employ a different, and hopefully better, approach to its publishing. Drew has assembled an "Editor's Board" consisting of several active Amateur satellite enthusiasts. In this way, Drew and Doug hope to better deliver the specialty information necessary to allow the Amateur satellite user to make the most of their station.

An Invitation

With this new editorial structure in place, we at AMSAT would like to invite YOU, the Amateur satellite USERS, to contribute your bits and pieces of Amateur satellite radio expertise to share with the rest of us Amateur satellite users. Please remember that at *The AMSAT Journal*, we do no profess to be experts at Amateur satellite communications techniques. However, we see ourselves as an excellent way to convey information about these techniques to all users.

We are free to entertain all ideas about the subject known as "Amateur Satellite Communications". Some of you who have been satellite operators for a few years may have developed some interesting methods used to operate AO-13 or the Microsats. Others may be having a problem with a particular antenna for 2 m uplinks. Some of you may find the receiver sensitivity of certain receivers for weather satellites are more desirable than others. Of course the beginners, poor boys, and operating procedures type of articles are always popular. All of these topics are possibilities for informative articles for *The AMSAT Journal*.

We are also interested in the little tidbits of information that you develop as an Amateur satellite operator, kind of a "Satellite Hints" or "Did you Know?" type of mini-article. Also, pictures are a great means of conveying information. So send us a picture of your station, your Field Day set up, or whatever you might think of as interesting to other Amateur satellite operators.

Conclusion

Remember, *The AMSAT Journal* is your publication as well as ours. We can't guarantee each and every submission will make it to print, but we will certainly consider each and every one as a possibility. As with anything else involving Amateur satellite communications, we can do amazing things if we all pitch in and work together! ■

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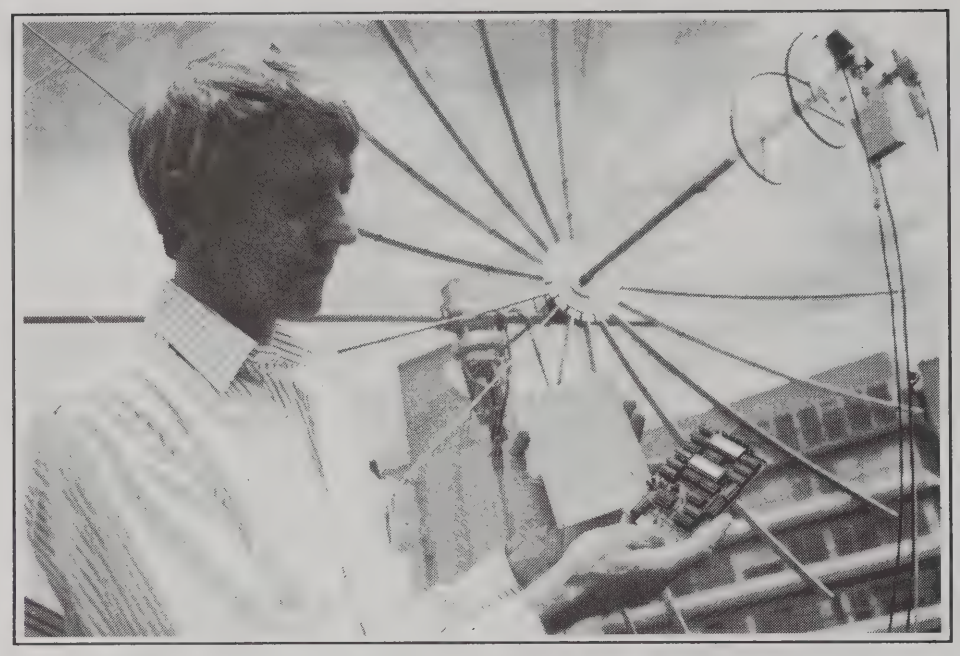

James Miller, G3RUH, pictured at the 1990 AMSAT-UK Symposium with a pair of his 9600 baud packet radio modems. He's well known for his designs (UO-11, AO-13, FO-20/PACSAT, UO-14), with some 3000 boards in worldwide use. A new all-digital (no setups!) state-of-the-art Mk II AO-13 design will be available shortly. James is one of the OSCAR 13 command stations, and wrote all the ground station attitude determination and associated analysis utilities used for mode schedule planning and all aspects of AO-13 management. Author of numerous articles, in 1984 James coined the now familiar term "squint angle."

The Shape of Bits to Come

This article originally appeared in the Journal of AMSAT-UK, Oscar News, *No. 88 April 1991. It is about bits, about bandwidth and about control of both.*

By James Miller, G3RUH

A number of terms have crept into articles on Amateur Radio data transmission recently. If my mail is anything to go by, they create both interest and puzzlement. What, for example, is the "raised cosine modulation" used on Microsats AO-16/18/19? And what is the RSM-8 on Rudak/AO-21? What PSK modulation does Fuji 20 use? Further, what do abbreviations such as BPSK mean? Read on.

Let's come clean at the outset; "raised cosine," RSM-8, PSK and DPSK are the same thing. They're all forms of PSK — "phase shift keying."

In the Amateur environment we are usually trying to send data as fast as possible within a limited RF bandwidth. This limit may be set by the receiver alone, or it may be due to some statutory, aesthetic or technical requirement. So a very important part of data transmission concerns the data's spectrum.

Understanding PSK

Let's begin with a statement: PSK spectral considerations at RF can be analyzed by examining the characteristics of an isolated bit at "DC," or baseband as it's known.

I have to start somewhere, so I'll make the assumption that you have in your head an image that "data" is the sort of regular signal you have running down a piece of cable. On a 'scope it looks like random highs and lows spaced at regular intervals. Each of these elements is called a "bit," and they flow at the "bit rate," described as 9600 bits/sec or sometimes "9600 baud" depending on the context. See the waveform "Data In" of Fig. 1.

There are many ways to modulate this data onto an RF carrier. Here I am concerned with double sideband modulation, DSB. That is, the data signal drives a balanced modulator whose other input is the RF carrier. The output then is simply a frequency shifted replica of the input data. (Think what would happen if the input were voice.)

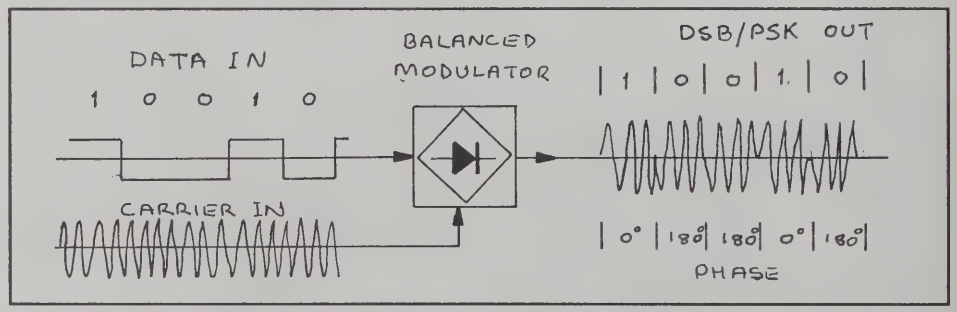

Fig. 1 — PSK is generated by a balanced modulator.

Now binary data has only TWO states. It is either a "1," represented by +1 volt say, or a "0," represented by -1 volt. And that means that the modulated RF carrier also takes only TWO states; either it has phase 0 degrees or 180 degrees. This is because compared with the +1 volt level, the -1 volt inverts the carrier. That means a 180 degree phase shift. Voila! Binary Phase-Shift-Keying or BPSK. The term PSK, often used, is actually imprecise as it embraces other shifts as well as 0/180 degrees. "Antipodal PSK" is correct but long-winded.

So, if we know the spectrum of the "baseband" data signal, then the RF spectrum is just its replica above and below the carrier frequency, because it's DSB. If in addition, the data signal has amplitude variations, then these will translate into identical amplitude variations at RF. This is a very important equivalence, and it's worth restating:

"Binary data DSB modulating an RF carrier" and "binary phase shift keying (BPSK)" are exactly the same thing. If we want to control or analyze the RF spectrum characteristics, we only need to control or analyze the source data characteristics.

Understanding Data Streams and Isolated Bits

We now make a reasonable assumption. The data stream consists of random bits. If the data is random, for the purposes of analysis we don't then need to know anything about the content of the message stream. All we need to know are the properties of ONE ISOLATED BIT. Whatever properties we can discover about the isolated bit will also apply to the average sum-

mation of the random assortment of them that make up the stream.

So in summary, our problem of spectral considerations at RF can be analyzed via the relatively simpler job of examining the characteristics of an isolated bit at source level, DC or "baseband."

Understanding Bit, Eye and RF Spectrum Plots

Now let's examine some representative cases. What happens if we modulate the carrier directly with unprocessed rectangular bits?

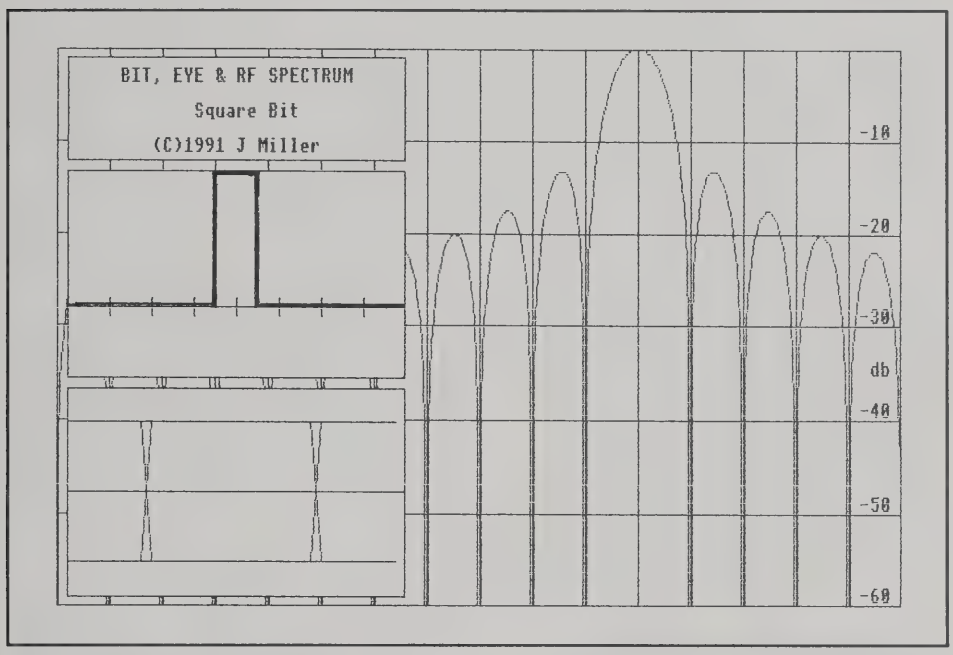

Fig. 2 — Rectangular bit, its eye and spectrum.

Fig. 2 shows three things, a) an isolated rectangular bit, b) its RF spectrum and c) what the data stream looks like on an oscilloscope. Of course the bit edges are in reality almost invisibly fast, so I have emphasized them slightly.

a) Isolated Bit. The horizontal axis is time, and is marked off in eight bit intervals. (Eight are shown.) The vertical axis is voltage.

b) RF Spectrum. The horizontal axis is frequency, and is marked off in units of the bit rate R bps. For example, if the data rate is 1200 bits/sec (R = 1200), the vertical markers are at 1200 Hz spacing. The mid point of this spectrum is of course the RF carrier frequency. The vertical axis is marked off at 10 dB intervals.

c) Oscilloscope diagram.

1. The horizontal axis is time, and spans a total of two bits; so it is expanded x4 compared with the isolated bit. The vertical axis is voltage. You are to imagine the 'scope is triggered by a local bit-rate clock. The resultant pile-up of bits is what you see displayed. It is the sum of many positive and negative isolated bits, each displaced in time by one bit.

2. If this display is the received waveform, it's what is sampled by the data detector to decide if a "1" or a "0" has been received. Usually this decision is taken at the mid-time point of the received bit by a sampler. Above the horizontal line is the regime of "1"s, below "0"s.

3. This display is also universally known as an "eye diagram." It is a concise representation of the quality of the received signal. The less confused the trace, and hence the greater the distinction between high and low at the mid-bit sample point, then the more reliable (less error prone) bit detection will be.

4. These traces show no channel noise. That is to say, the signal to noise ratio is assumed high. If there were noise, the traces would be blurred. If the noise were momentarily large enough to cause the waveform to cross the middle horizontal line, an erroneous detection decision would be made, leading to a received bit error.

Rectangular Bit

Returning to our rectangular bit shape. Two things are clear from Fig. 2; first, the high fidelity of the data waveform and second, the price for this, a profligate use of bandwidth. The diagram shows significant energy spreading well beyond 10 times the data rate. Indeed, as far away as 30 R, the side lobes are still only -40 dB down. As sufferers from computer hash will know, rectangular bits are effective noise generators.

In some applications (for example spread spectrum communications) this might be the desired result. In the Amateur Radio environment where we want to get as much data as possible through the limited bandwidth of our receivers, a more refined approach is needed. Obviously we need to filter the data stream before transmission, because this will attenuate those side lobes, and so constrain the bandwidth. So the key issue, indeed perhaps the central problem of all data transmission, is "What form should this filter take?"

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Performance of a Simple R-C Network Data Filter

We tentatively try a simple filter. Let's pass the data stream through an R-C network with a -3 dB point equal to half the data rate. The result is shown in Fig. 3. Look at the spectrum; while the main lobe is hardly changed, the side lobes are reduced by 10 dB or more, which is what we wanted. Look at the isolated bit; it has become rounded. But note particularly that its duration now exceeds one bit. In fact it's roughly two bits long. This means that successive bits overlap. In turn this brings a new potential design problem; inter-symbol interference, or ISI. Now we find that not only do we want spectrum control, but we have to do it with the constraint that successive overlapping bits must somehow not interfere with each other.

Finally, look at the 'scope trace. The line at the top corresponds to the sequence 111..., that at the bottom 000.. . The sweeps from top to bottom are caused by ..10.. and ..01.. transitions and so on. You can also see that the traces are not confused; highs and lows of successive bits are separated so inter-symbol interference is scarcely evident here.

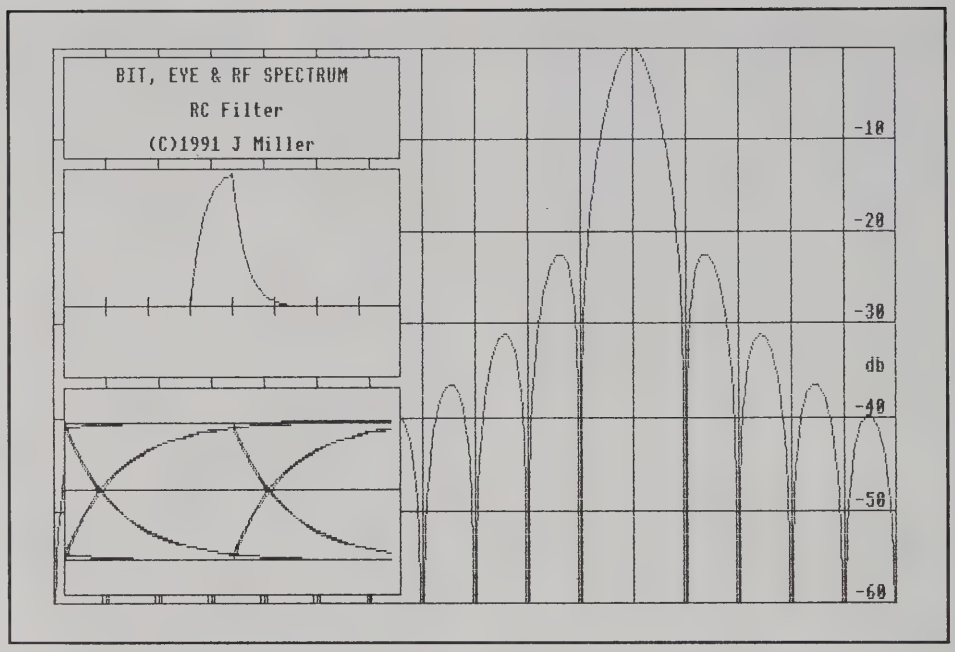


Fig. 3 — Rectangular bit through R-C filter.

Inter-symbol Interference Revealed

In an attempt to attenuate the side lobes more, let's now double the RC filter's time constant. That is, the -3 dB frequency is now 1/4 the bit rate (R/4). See Fig. 4. Though the side lobes are reduced, the main lobe is also rather pinched now. But the real casualty can be seen in the 'scope trace. Under certain conditions (for example the sequence ..010.. or ..101..) the voltage barely gets half way up to the top line. Sure, bits are still distinct and detectable, but the noise margin is reduced by some 50%.

Analytically, the reason for this is seen in the isolated bit diagram of Fig. 4. The bit starts off at T=0. At T=1 it reaches its peak. At T=2, it hasn't fallen back to zero again, but has a value approximately 1/3rd peak. This aberration is the sole cause of the inter-symbol interference apparent in the 'scope trace. At T = 3, 4 etc., the voltage is back to zero again.

From this observation we can formulate the requirement for a bit shape that guarantees no ISI. There should be a peak of unity at T=0. Then at all other bit points (T= -2, -1, +1, +2, etc.) the isolated bit waveform should be exactly zero. What happens in between doesn't matter.

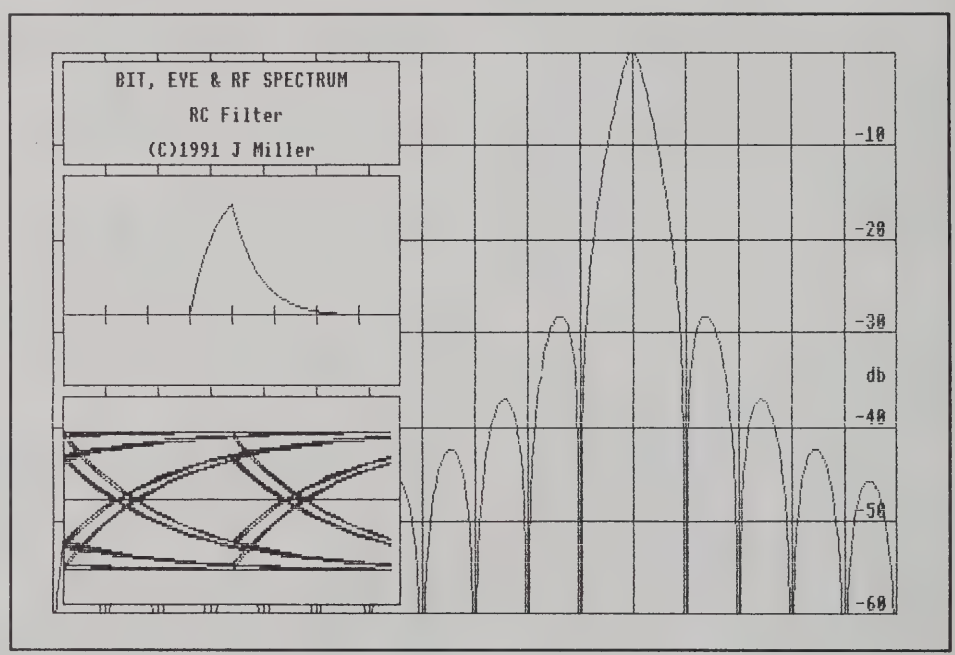


Fig. 4 — Too much filtering gives I.S.I.

FO-20's Data Filter

An example of a bit shape that meets this requirement is that transmitted by the satellite FUJI-OSCAR 20. The data filter is (I believe) a 3rd order Bessel type with a -3 dB point at 0.532 times the bit rate (0.532 R). "Bessel" filters have a nice steady rise, and negligible overshoot or ringing. In electrical circuit terms, the filter is merely 3 resistors, 3 capacitors and an op-amp. The filter is shown in Fig. 5 and the responses are shown in Fig. 6.

The spectrum is quite reasonably controlled; 99.9% of the energy is contained within a bandwidth of 1.75 R (as compared with 15 R of the rectangular pulse). Since the FO-20 bit rate is 1200 bps, this means that most of the signal occupies an effective RF bandwidth of the order of 2.1 kHz, so it stands a fair chance of passing through the relatively wideband SSB receiver filters without significant distortion.

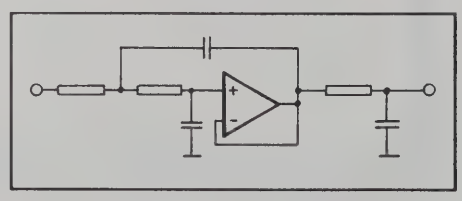


Fig. 5 — FO-20's 3rd Order TX Data filter.

The isolated bit shape is zero at all T points except at one, and this leads to a nice 'scope trace. The origin of the term "eye diagram" can be seen here, as the trace is supposed to resemble a human eye. Notice that as a consequence of negligible inter-symbol overlap in the isolated bit, the 'scope trace has perfect bit convergence at the sample point.

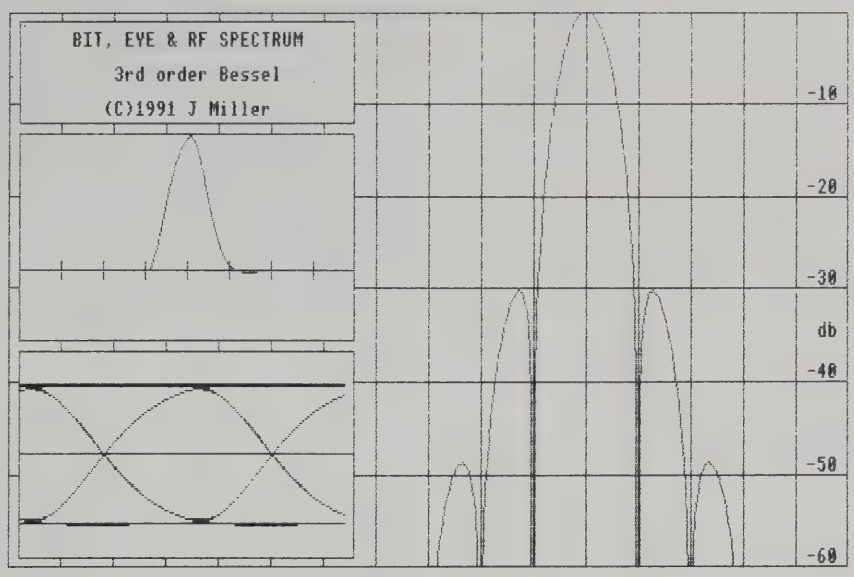
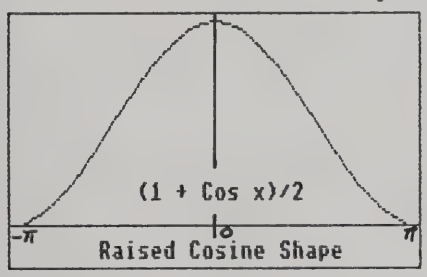


Fig. 6 — Characteristics of FO-20 Data.

The isolated bit has a duration of just 2 bits. This means that there can be only 22 = 4 trajectories on the 'scope trace (00, 01, 10, and 11). The 01s and 10s show up as a very clean zero crossover. If the RF bandwidth were narrower then the isolated bit would span more than 2 bits, so the 'scope trace zero crossings would show dispersion.

And Now "Raised Cosine"

The term "raised cosine" means several things, a fact which causes a lot of confusion. A raised cosine is just that. A cosine function raised above its mid point.



A raised cosine shape.

The formula for a raised cosine is (1 + COS x)/2. Drawn as a graph, it's merely a shape. But it has a number of analytical properties that make it convenient to employ. These are simplicity, and left-right and top-bottom symmetries.

A Raised Cosine Bit

"Raised cosine" can for example, describe the shape of the isolated bit — see Fig. 7. Since the isolated bit is cosine shaped, the 'scope trace is composed entirely of sine waves and straight lines. Indeed, the bit sequence ..10101010.. creates a pure tone at a frequency R/2 at baseband, or at RF, two frequencies spaced by +/- R/2.

The isolated bit shape is very similar to FO-20's, occupying 2 bits. Not surprisingly the spectrum is very similar too. In fact 99.9% of the energy is contained within 1.69 R (compared with 1.75 R for FO-20). An important practical point to remember is that the shape of the bit is completely specified. This means that it can be generated exactly using real finite hardware. The Microsats AO-16/WO-18/LO-19 use a filter like this.

The Raised Cosine Spectrum

Alternatively "raised cosine" can also be used to describe the shape of the spectrum. This is illustrated in Fig. 8. It doesn't look much like a raised cosine spectrum

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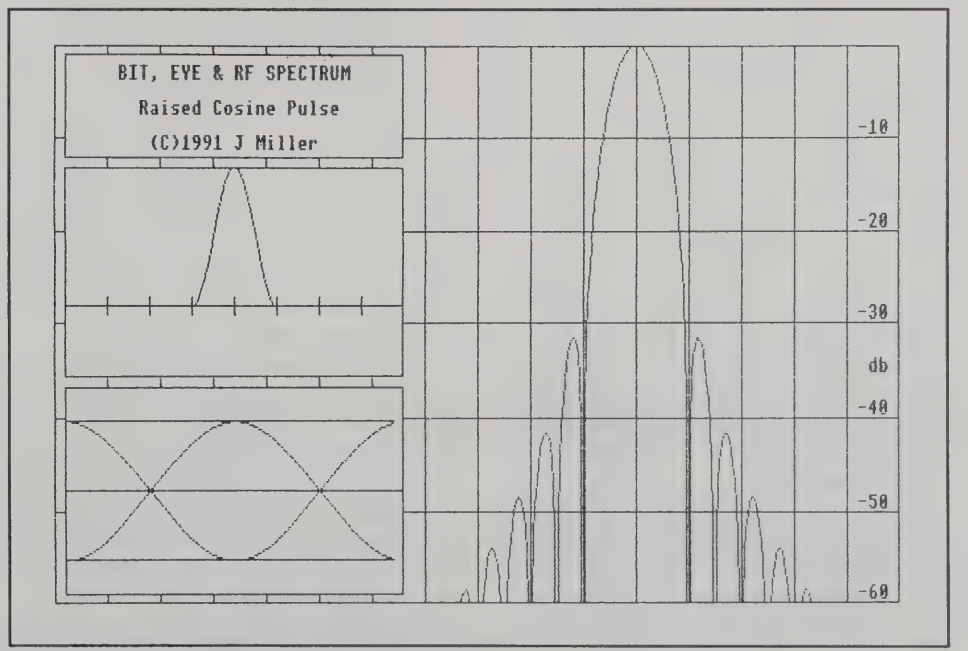

Fig. 7 — Raised cosine bits, AO-16/WO-18/LO-19.

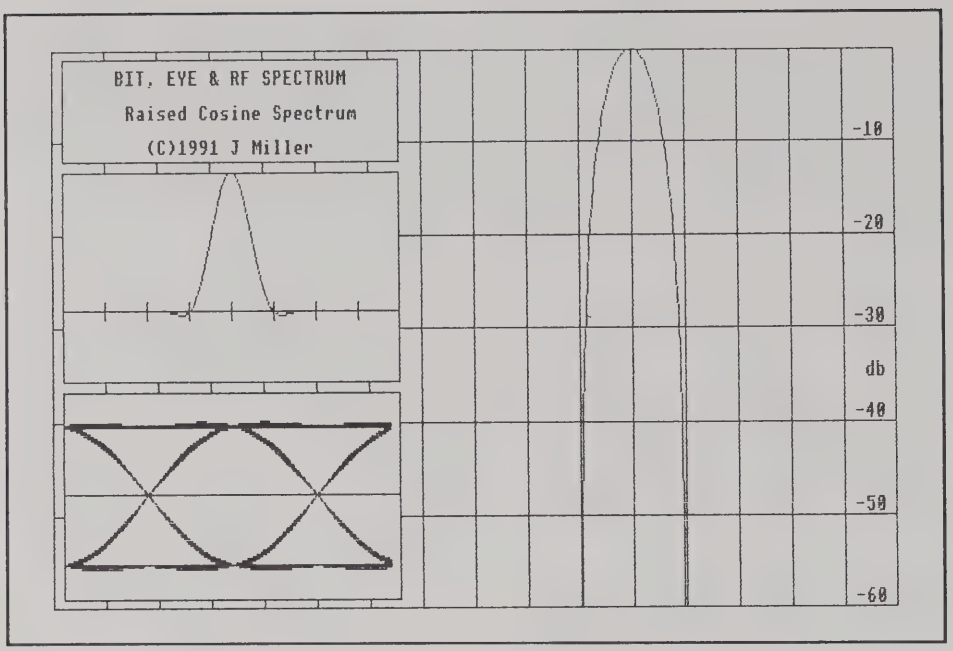

Fig. 8 — Raised Cosine Spectrum Shape.

because of the logarithmic scale, but the response is unity (0 dB) at f=0, 0.5 (-6 dB) at f = R/2 and exactly zero at f = R, the bit rate. 99.9% of the energy is contained within 1.56 R.

Because the spectrum is absolutely band limited to +/- R, the isolated bit shape that gives rise to that spectrum has infinite time duration. This means that it cannot be exactly synthesized. On the other hand, as Fig. 8 shows, it has negligible amplitude beyond T = +/- 2 bits, so that discarding the tails has little effect other than to bring in some very minor spectral side lobes.

You will notice that the isolated bit also has precisely the desired properties for zero inter-symbol interference. Is this fortuitous? Certainly not! In fact it is a direct consequence of the two symmetries of the cosine shape mentioned earlier. That's why the raised cosine spectrum is widely used in data transmission system design.

9600 Baud Packet Radio and UoSAT 14 — A Narrowband Raised Cosine Spectrum

As a practical example of "raised cosine" spectrum shaping consider Fig. 9. Here only the middle 3/8ths of each half of the spectrum is given a raised cosine shape. From f = 0 to 5/16 R the spectrum is flat (0 dB), from 5/16 R to 11/16 R it follows the cosine shape, and from 11/16 R onwards the spectrum is zero.

This is used in the baseband filtering of UOSAT-3/ Oscar 14 which uses the G3RUH 9600 baud Packet Radio Modem [1]. The isolated bit shape spans some eight bit periods. That is to say a bit transmitted "now" will actually have an influence on up to eight other bits, four before and four after "now". Note also that the isolated bit has the desired form for minimizing inter-symbol interference. A peak at T = 0, zero at all other T points. So the received "eye" shows good convergence at the sample point.

The spectrum is almost rectangular ("brick-wall") and side lobe free. And 99.9% of the spectral energy is contained within 1.2 R, or +/- 5.6 kHz at 9600 bps.

The zero-crossing dispersion is a direct consequence of the narrow bandwidth, and great care is needed in the design of the receiver bit-clock recovery circuits that perform time bit detection.

The actual signal transmitted by UO-14 is slightly different from that shown; it is pre-distorted (in time) so that when it passes through a real bandwidth limited receiver the final "eye" is as illustrated. In UO-14 the signal also FM modulates the carrier (as opposed to PSK). FM is simple to generate, much simpler to process on receive in the presence of mistuning such as Doppler shift, and is very robust. But FM does require slightly stronger signals.

Importantly, the data shape shown could trivially generate BPSK via a DSB balanced modulator. Such PSK would have all the narrow-band and non-ISI attributes detailed above.

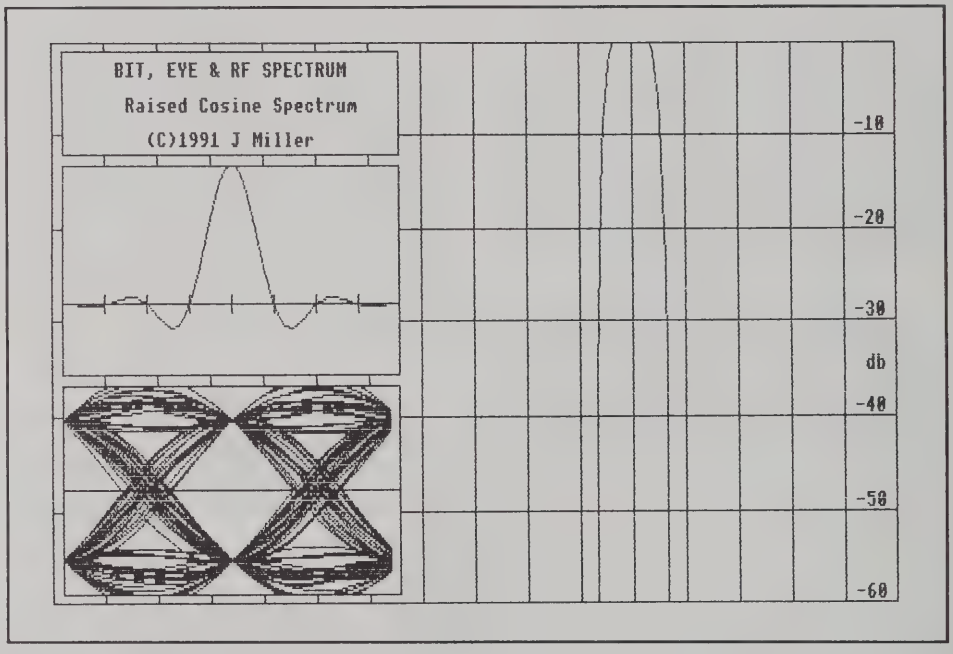

Fig. 9 — UOSAT 14 has "rectangular" spectrum.

Transmitter and Receiver Filtering in Series

So far discussion has mostly been about spectra and bit shapes in association with transmitters. It was implicit that the receiver was infinitely wideband. For analytic purposes, if it had filtering it could be assumed to be merged with the transmit filtering.

In many Amateur applications this is indeed the case. For example, the current flock of PSK packet satellites confine their bit rates to that which can be passed through a typical SSB receiver. RTTY users assume the same thing.

We now ask the important question; if the overall filtering were to be deliberately split between transmitter and receiver, what should be the form of the filters? We know from all the above what kind of overall response is required. But how should we partition it?

Obviously, the overall response can be apportioned in any ratio whatsoever. However one can prove that in the presence of

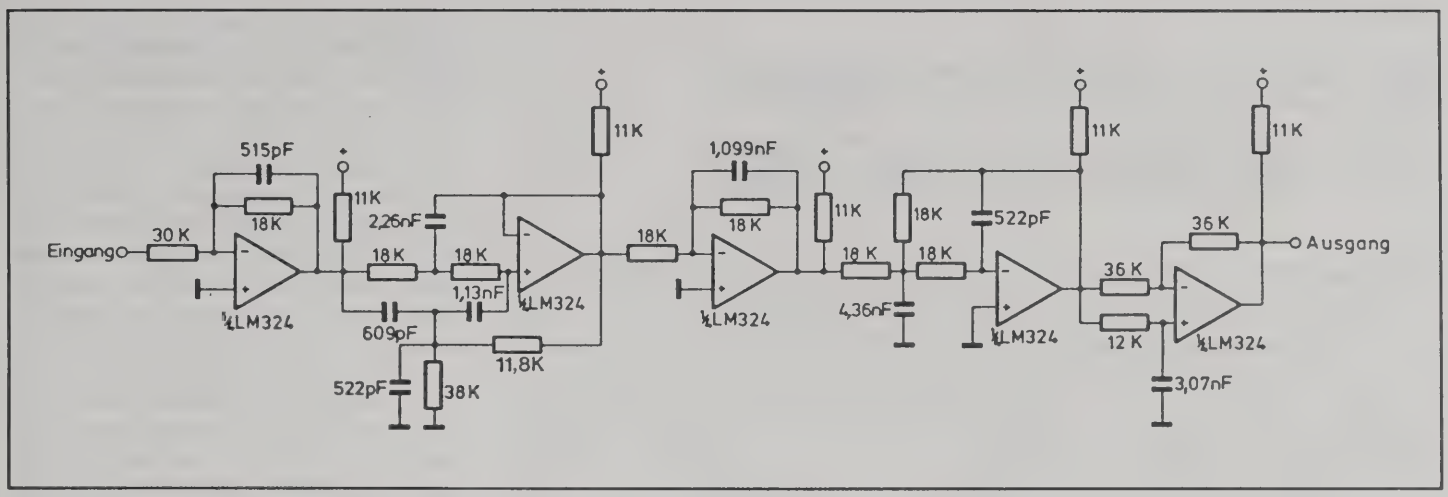

Fig. 10 — Data filter used in RUDAK-2 "RSM" transmitter.

random noise the optimum split, so as to maximize detector signal-to-noise ratio, is that with exactly half the frequency response in the transmitter, and the other half in the receiver. These are known as a "matched filter pair."

Conceptually, one can first imagine a desired overall frequency response dictated by inter-symbol interference requirements, spectral constraints and implementation ease. Then as it were, you take the "square root" of this, and put the resulting filter into both transmitter and receiver.

AO-21/RUDAK-2 "RSM" Bit Shaping

A very good example of this is the bit shaping scheme used on one of the RUDAK-2 links of AO-21 [2]. Winningly dubbed "RSM" Rectangular Spectrum Modulation by its creator, its transmit filter properties are shown in Fig. 11 (below). Both transmitter and receiver have essentially identical filters. This bit shape is used to phase modulate (BPSK) the RF carrier. Bit rate is R = 9600 bps.

Nearly all, 99.9%, of the spectral energy is contained within a bandwidth of 1.5 R, which is consistent with the isolated bit span of about 3 bits. This means that there are about 23 = 8 trajectories in the 'scope trace, which can be seen quite clearly. It is notable that this isolated bit shape is created using analog filtering rather than more accurate and repeatable digital synthesis.

The transmit filter (Fig. 10) has 3 sections, comprising a) a Cauer-Chebyscheff type CC0315/41 which is flat up to a frequency f = R/2, and then plunges down to the zero at f = R. But above this there is a rise to only -15 dB. So part b) is a 3rd order Butterworth that's smooth to the -3 dB point at f = R/2, and then -18 dB at f = R and -36 dB at f = 2R; c) an "all-pass" network that has a dead flat frequency response, but a tapered phase characteristic which is used to flatten out the filter delay vs. frequency curve. This makes the transmit bit shape become left-right symmetric. This filter is not driven directly by the rectangular bit stream, but by short + or - pulses of polarity corresponding to the data bit's polarity.

When cascaded with an identical analog filter in the receiver, the overall response is as per Fig. 11. The overall isolated bit shape is almost perfect, spanning some 5 bits with remarkable symmetry. The 'scope trace shows an excellent eye. The sample point convergence has about +/- 8% scatter due to the slight non-zero values of the isolated bit shape at T = -2 and T = +2.

The Future?

The 9600 baud RSM-PSK implementation is near optimal in performance, prob-

(Continued on page 30)

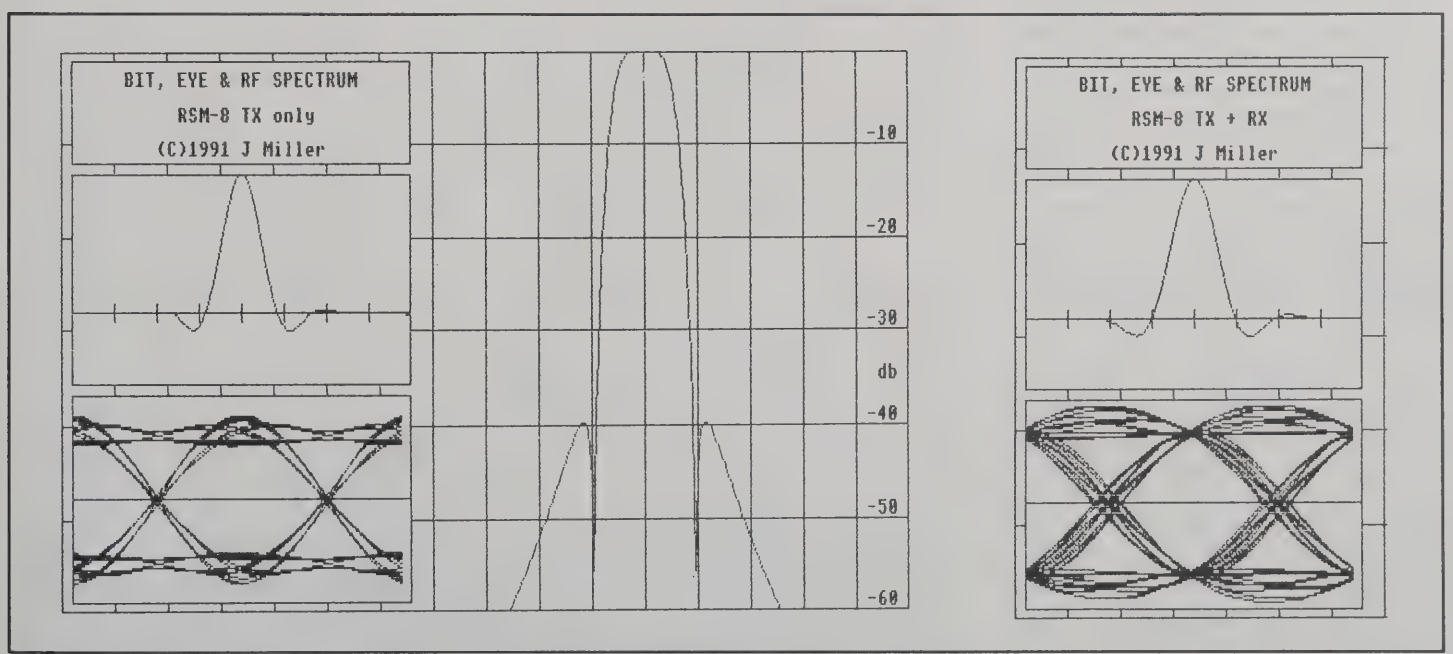

Fig. 11 — RUDAK-2's "RSM". (L) TX filter. (R) TX and RX filters cascaded.

An Easy to Homebrew 435 MHz Crossed Yagi

The following is a re-print of an article first published in the May 1989 issue of 73 Amateur Radio *magazine. Since then, the authors have both received many phone calls from folks who have actually built and have this antenna in use. Most of the feedback has been very positive and the builders tend to be surprised at how easy the antenna is to build and tune up, not to mention how well it performs.*

Doug, KG5OA, has had the original antenna in service for about 2-1/2 years. His link calculations show that the actual antenna gain is a little over 12 dB as compared to the theoretical prediction of almost 14 dB. Doug achieved a Mode J/L level Z-8 in the 16 June 1990 ZRO test with the antenna up 26 feet using a WA5VJB preamplifier and about 35 feet of 9913 coax. Also included in this article is a three dimensional diagram (Figure 3) which is a "herringbone" display of the entire antenna.

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(817) 292-6440

So many people that I've talked to in the AMSAT booth at the various local Hamfests tell me, "I'd like to get into satellites, but I can't afford the equipment!". I tell them that Amateur satellite operation is like any other facet of Ham Radio; you can go down to your favorite radio store, "whup" out your checkbook, and buy everything you need for many kilobucks. OR, you can pick up used gear for much less than new prices, AND, where possible, save even more by homebrewing some of your equipment. One essential piece of satellite equipment that is within most peoples' ability to homebrew is the 435 MHz antenna.

Materials

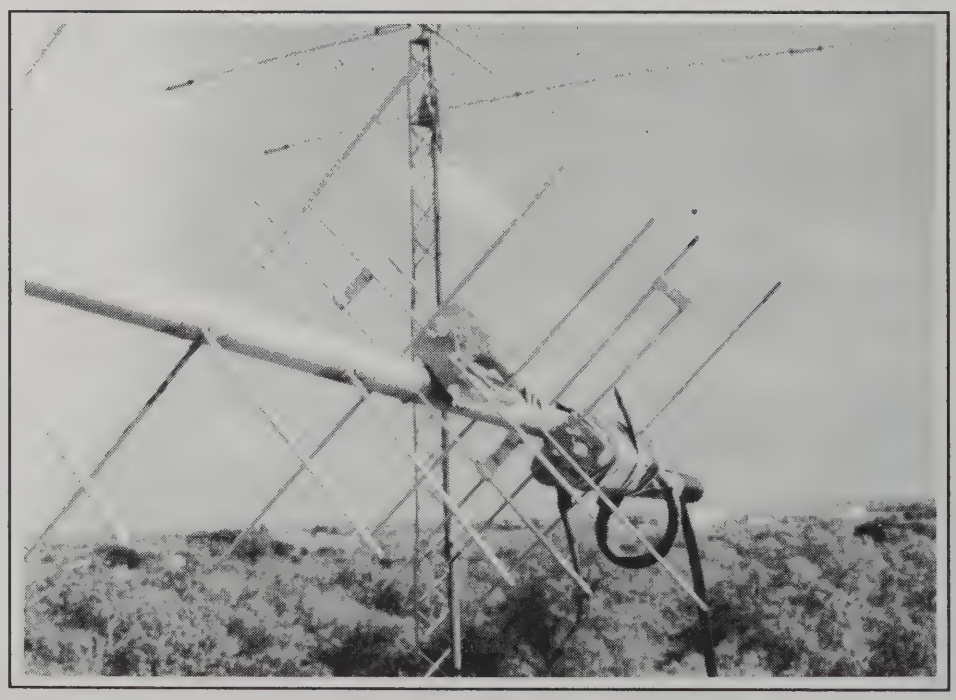
My personal experience has shown that you can walk into a well equipped hardware store and, for twenty bucks, walk out with virtually all the materials that you need for a fine 435 MHz circularly polarized crossed Yagi. The antenna that I'm going to describe to you was manufactured by Doug, KG5OA, and myself and is made from materials that are very common and should be easy to find.

The boom was made out of a 10 foot piece of 3/4 inch copper plumbing pipe. As will be discussed in the next section, this is just right for a crossed Yagi having 15 elements in each plane. Common 1/8 inch fluxless brazing rod was used for the elements. This material comes in three foot long rods and is sold by the pound at the local welding supply. Three pounds worth was purchased with some left over. The copper pipe and the brass brazing rod were chosen for their rigidity and their ability to be soldered together (not to mention their availability). The total cost of the above mentioned materials came to just under $17.00. In addition to the above materials, in order to complete the antenna, two N-type panel mount connectors were required. N-type connectors were used because of their good 50-Ohm impedance performance at 435 MHz. DO NOT use the PL-259 / SO239 type connectors at this frequency.

The Design

A crossed Yagi is nothing more than two identical, perpendicular Yagis sharing a common boom. Circular polarization is generated when one of the antennas is fed one quarter of a cycle (90 degrees) later than the other. This 90 degree phase shift can be generated in one of two common ways. First, if the two antennas are constructed so that all similar elements are mounted on the boom at the same location, then the delay can be generated by feeding the antennas with a phasing harness having one leg a quarter of a wavelength longer than the other. This is sometimes referred to as the "time delay" method. The second way that the necessary delay can be generated is by physically constructing one Yagi one quarter wavelength in space in front of the other on the boom. If this method is used, both antennas are fed in phase. We selected the latter method for ease of construction without sacrificing performance.

The element lengths and locations were determined using a Basic language computer program written by David G. Hopkins, VK4ZF, based on research done by Gunter Hock, DL6WU. I liked this program because it let me tailor the antenna dimensions based on the materials that I could easily obtain. It also gave me the option of having the elements electrically connected to or insulated from the boom (their lengths would be different). I chose the method of having the elements electrically connected because direct soldering



made construction easier.

The dimensions of all of the elements and their placement on the boom can be found in Table 1. The two antennas are identical in every way except that one whole antenna is shifted 6-25/32 inches (17.22 cm) ahead of the other. To help in construction, I will differentiate between the two Yagis by calling one the "vertical Yagi" and the other the "horizontal Yagi", even if it isn't quite technically correct.

Construction

The first order of business was to drill all of the necessary holes in the boom. The copper pipe was cleaned with some steel wool and then the locations of the "vertical" antenna elements were marked on the boom. If I were going to make thousands of these antennas I would have made a permanent metal jig. But, since only one antenna was constructed, we made do with the materials at hand. The drilling "jig" that we used consisted of a 10 foot piece of relatively straight 2 X 4. The copper boom was placed on the jig, which slid next to a guide fence clamped to the metal platform of the drill press. The fence was used to keep the jig in the same position so that all holes were drilled straight through the center of the boom. A 1/8 inch hole for the reflector was drilled all the way through the boom and the wood. Then, in order to hold the boom in place to drill the rest of the elements, a 1/8 by 2-1/2 inch bolt was placed through the wood and through the boom. When all of the vertical antenna element holes were drilled, the bolt was removed and the boom was rotated 90 degrees. The above process was repeated for all horizontal elements.

After this was completed, it was time to take the brass brazing rod and cut out two identical sets of 15 elements. The elements were cut with a hacksaw and then ground to length. You should try to keep the lengths of your elements to within 1/64 to 1/32 inch of given dimensions. In order to tell the difference between elements, a two inch piece of masking tape was placed on the end of each element and labeled (D1, D2, D3, etc.).

At this point, each element was marked so that it could be accurately centered in the boom for soldering. A pencil mark was placed in the exact center of each element. Then, another mark was placed 3/8 inch on either side of this mark. When the element is placed through the boom, these outer marks are just visible.

Soldering of the elements took place with the boom placed on top of two sawhorses. The boom was cleaned with steel wool and flux paste was applied around each hole and each element. The elements of the horizontal antenna were soldered

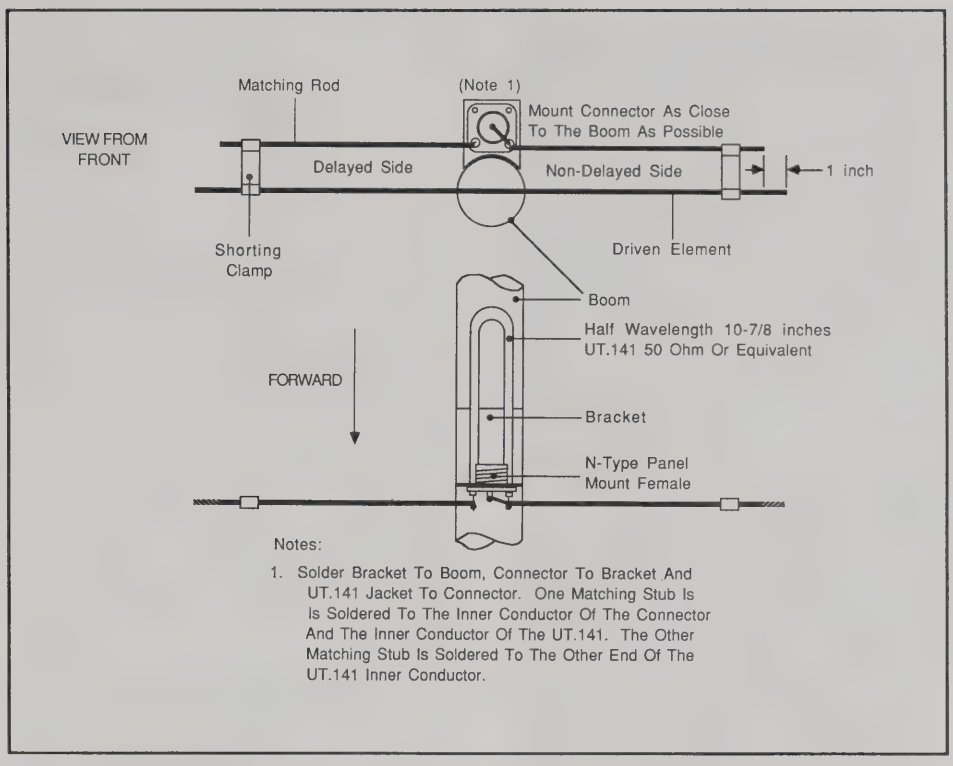

Matching Rod
(Note 1)
Mount Connector As Close To The Boom As Possible
VIEW FROM FRONT
Delayed Side
Non-Delayed Side
1 inch
Shorting Clamp
Driven Element
Boom
Half Wavelength 10-7/8 inches UT.141 50 Ohm Or Equivalent
FORWARD
Bracket
N-Type Panel Mount Female
Notes:
1. Solder Bracket To Boom, Connector To Bracket And UT.141 Jacket To Connector. One Matching Stub Is Is Soldered To The Inner Conductor Of The Connector And The Inner Conductor Of The UT.141. The Other Matching Stub Is Soldered To The Other End Of The UT.141 Inner Conductor.

Fig. 1 — The Tee Match.

first, three at a time. Heating was accomplished with an ordinary butane torch.

After all of the horizontal elements were secured, the antenna was rotated 90 degrees so that the vertical elements could be attached. All vertical elements were soldered (now resting horizontally) in the same manner. While soldering some elements, some problem may be encountered with the solder of nearby, previously soldered elements becoming soft and the element falling out. This can be helped by attaching a pair of vise-grips to the affected element to act as a clamp and heatsink.

The Match

After all of the elements from each antenna had been soldered in, it was time to hook up the matching system. I have found that the T-match works very well at this frequency and is easy to tune. The construction details for the T-match can be found in Fig. 1. The delay line / balun was constructed using a 1/2 wavelength piece of .141 semi-rigid 50 ohm cable and was directly soldered through the bottom two holes of the N-type panel mount connector. The length of the cable was cut to 10-7/8 inches, which is shorter than 1/2 wavelength in space, due to the velocity factor of the cable. If you can't find any .141 semi-rigid, you may try a piece of RG-58, although the assembly procedure may change.

The N-type connector was mounted on a 1-1/8 by 2-1/2 inch wide piece of copper made from a section of 3/8 inch copper refrigerator pipe. A hacksaw was used to cut a 1-1/8 inch ring of pipe. The ring was then cut laterally and opened up to form a rectangle. The rectangle was then bent into an "L" shaped piece which was drilled to accommodate the N-type panel mount connector. The shorting clamps are made of a 1/4 inch wide piece of copper fashioned in the same manner. The matching rods were made out of the same 1/8 inch brass rod as the elements.

In order to achieve right-hand circular polarization, (which is the convention on OSCAR 10 and OSCAR 13) the T-matches must be constructed so that the non-delayed side of the vertical (forward) antenna is pointing "up" and the non-delayed side of the horizontal (aft) antenna is clockwise from it while looking forward along the reflector end of the boom.

Tune-up

The tune up of this antenna was really quite simple. A Bird directional wattmeter or SWR-bridge rated for the frequency was inserted in the line as close to the antenna as possible. Tune for lowest reflected power by sliding the shorting bars in and out. Keep in mind that the bars should be located equidistant from the center of the boom. When the correct placement of the shorting bars was determined, they were soldered in place. An SWR of less than 1.2: 1 was easily obtainable on each antenna.

The Phasing Harness

If you are going to feed two 50 Ohm antennas with one 50 Ohm coaxial cable

you'll need a phasing harness. This phasing harness not only splits the power between each antenna, it also matches the impedances.

The phasing harness of Fig. 2 was constructed to feed both antennas in phase, thereby producing right-hand circular polarization. Any odd quarter wavelength of 75 Ohm cable will transform 50 Ohms up to 100 Ohms. Two 100 Ohm systems in parallel equals 50 Ohms. For ease of construction, it was decided that a 3/4 wavelength piece (taking into account the velocity factor) of cable on each side would work well.

Author Doug Howard shown at antenna level.

The harness was connected to both antennas and taped or tie-wrapped close to the boom. It would be a good idea to recheck the SWR of the system at this point. It should still be quite low.

Final Preparations

Before the antenna can be installed, one or two more things should be done. First, it would probably be a good idea to paint the antenna. Some knowledgeable people have told me that, due to the crystalline grain structure of brass, constant exposure to the outdoor elements will make it brittle. Painting the antenna will help this, as well as make it look better (I chose sky-blue).

Another thing that may be helpful is to somehow plug the ends of the boom. If you don't, insects, such as wasps and spiders, will make their homes there. I chose to plug the ends with a glob of silicon "pookie". This seems to have done the trick.

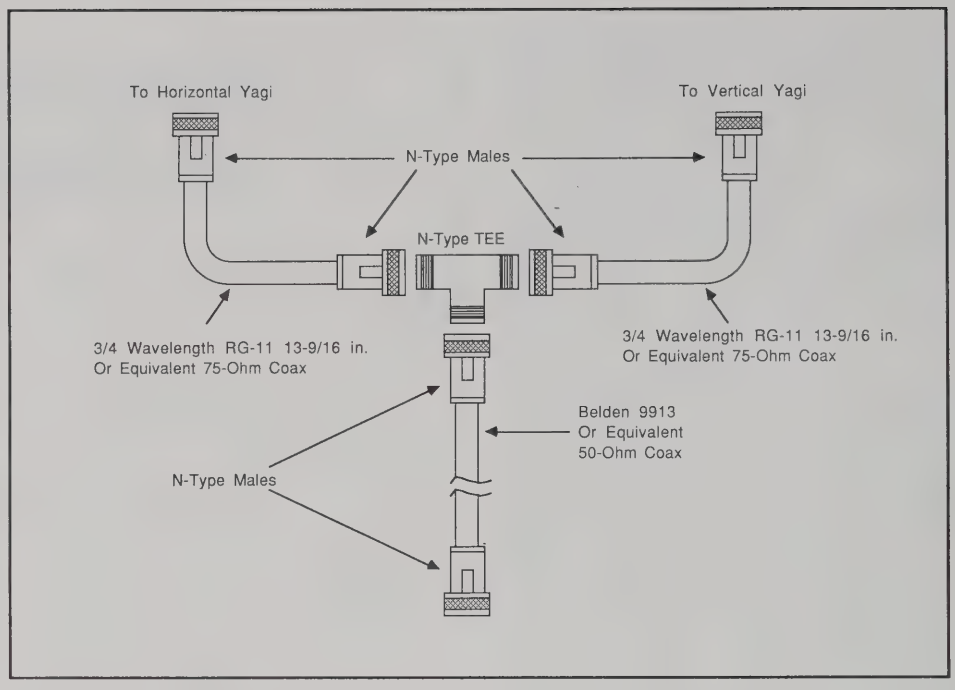


Fig. 2 — The Phasing Harness.

Results

The completed antenna was placed into service at the QTH of KG5OA about six months ago. Though no official gain measurements have been made, the antenna seems to work as advertised. In Mode B, QSOs through OSCAR 10 and OSCAR 13 are easily achieved with 10 to 40 Watts output depending on satellite attitude. In Mode J the many QSOs have been made with the antenna mounted above the HF antenna, with 75 foot of 9913, and the preamp in the shack.

I hope that you try to home brew at least some of your satellite station. Antennas are a good place to start. You don't have to use the exact materials or the exact methods presented here, I'm sure that other methods will work as well. Just be innovative and use the materials that are probably all around you. Good Luck and see you on the Bird. ■

70 CM CROSSED-YAGI DESIGN DETAILS:

DESIGN FREQUENCY:	435.30 MHZ
WAVELENGTH:	26-13/16 IN
NUMBER OF ELEMENTS:	15
DIAMETER OF BOOM:	3/4 IN
DIAMETER OF ELEMENTS:	1/8 IN
ELEMENTS ARE ELECTRICALLY CONNECTED TO THE BOOM!!!	
MAXIMUM PRACTICAL GAIN:	13.95 dB OVER A DIPOLE

ELEMENT LENGTHS (INCHES)

REFLECTOR	13-19/32	DIRECTOR # 7	11-19/32
DRIVEN ELEMENT	12-29/32	DIRECTOR # 8	11-1/2
DIRECTOR # 1	12-9/32	DIRECTOR # 9	11-7/16
DIRECTOR # 2	12-5/32	DIRECTOR # 10	11-3/8
DIRECTOR # 3	12-1/32	DIRECTOR # 11	11-5/16
DIRECTOR # 4	11-29/32	DIRECTOR # 12	11-9/32
DIRECTOR # 5	11-25/32	DIRECTOR # 13	11-7/32
DIRECTOR # 6	11-11/16		

DISTANCE FROM REFLECTOR END OF BOOM (INCHES)

ELEMENT	HORIZONTAL YAGI	VERTICAL YAGI
REFLECTOR	2-1/2	9-9/32
DRIVEN ELEMENT	9	15-25/32
DIRECTOR # 1	11-23/32	18-1/2
DIRECTOR # 2	16-19/32	23-3/8
DIRECTOR # 3	22-7/16	29-7/32
DIRECTOR # 4	29-7/32	36
DIRECTOR # 5	36-25/32	43-19/32
DIRECTOR # 6	44-15/16	51-23/32
DIRECTOR # 7	53-15/32	60-1/4
DIRECTOR # 8	62-13/32	69-3/16
DIRECTOR # 9	71-25/32	78-9/16
DIRECTOR # 10	81-17/32	88-5/16
DIRECTOR # 11	91-11/16	98-15/32
DIRECTOR # 12	102-1/8	108-15/16
DIRECTOR # 13	112-23/32	119-1/2

Table 1

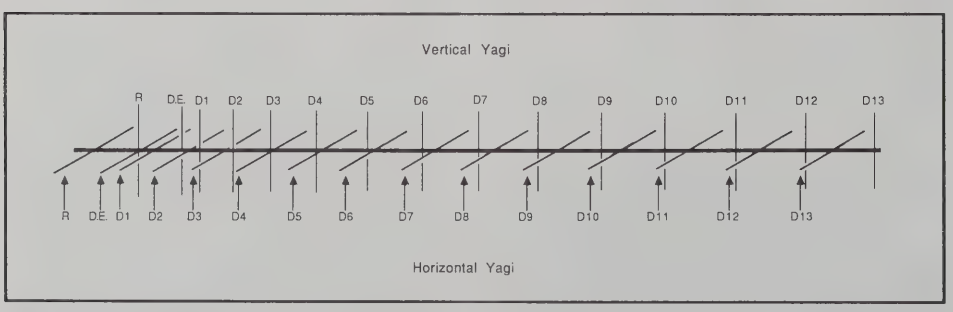


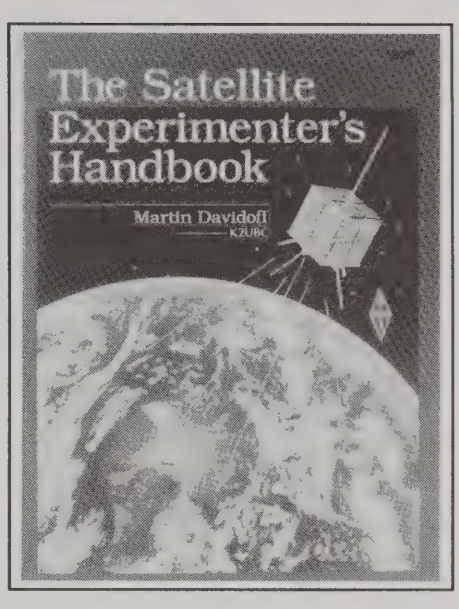
Fig. 3 — The 435 MHz Crossed Yagi.

A Beginners Guide to OSCAR 13, by Keith Berglund, WB5ZDP, is a step-by-step guide to getting started on OSCAR 13. $7 in the U.S., $8 in Canada and Mexico, $10 elsewhere. Call AMSAT Hq., 301-589-6062 to order.

The *Satellite Experimenter's Handbook*, 2nd Edition

Martin Davidoff, K2UBC
ISBN 0-87259-318-5
The American Radio Relay League
225 Main Street
Newington, Connecticut 06111
$20.00 (order Number 3185)

Reviewed by Courtney Duncan, N5BF,
AMSAT-NA V.P. Operations



Amateur Satellite enthusiasts are generally aware of the basic reference work for the satellite "corner" of the hobby, the *Satellite Experimenter's Handbook* which first appeared in 1985. A new, 2nd Edition is now available which is significantly expanded and updated. To compare the 1st and 2nd Editions of the *Handbook*, one might get the impression that, in terms of information and background needed by satellite users, the last six years have seen as much change and expansion in the service as the first 24, beginning with OSCAR 1 in 1961.

My very first impression of the 2nd Edition was to notice that the word "Experimenter's" was still in the title. It will be nice someday to see a book called the "Satellite User's Handbook" or the "Satellite Operator's Handbook" which contains the sum and substance of what is needed to effectively use satellites for routine communications, but that day is not yet here nor is it on the horizon. It still requires significant additional knowledge (beyond that required just to obtain a license and get on the air), understanding, and possibly experience to become a satellite "regular." This will likely continue to be the case for the foreseeable future.

The new edition is about twice the size (and cost) of the 1st Edition. As I progressed through the chapters in the reviewing process, one quality stood out. This book is thorough, thorough, thorough as might be expected from an author who is a professor of mathematics. There is considerable treatment of many of the theoretical background concepts needed for various facets of satellite operation, peppered with copious examples. There are many practical sections and there is much common sense discussion, advice, and guidance. As AMSAT knows all too well, it is not easy to set up and operate a satellite station without some elmering. Used carefully, an average Amateur Radio operator should be able to achieve that goal using this book. Every possible subject is not covered in exhaustive detail, but every subject that is covered is exten-

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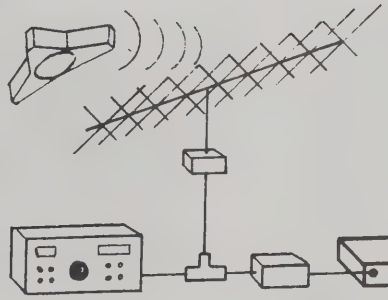

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sively referenced. There are enough pointers on nearly every page to get you started down a path to successfully unraveling nearly any problem (if you have the persistence) or question you are likely to encounter.

When I pulled out my copy of the 1st Edition for comparison, a bookmark (dated 1988) fell out. On it it said, "Overwhelming! Amateur Radio in the space business: Education, Science, Communication." This manual, in both editions, is the indispensable reference on the topic.

The *Satellite Experimenter's Handbook*, 2nd Edition, breaks down into three logical sections: (just like the 1st Edition) Introduction; Fundamentals; For The Advanced Enthusiast; plus Appendices, Glossary, and Index.

In "To the Reader", at the front, the author encourages readers, in their enthusiasm to get on the air, not to skip the introductory chapters which provide an historical overview of the Amateur satellite program (all the way back, actually, to Sputnik). Even if you do skip to the middle initially, I vote with the author on this advice. Someday you will ask or be asked questions like "Why aren't there more Mode A satellites?" or "Why is all the DX on Mode B?" or "Why is some new piece of equipment required for every new satellite?" ("experimenter's," remember?), or "Why is there Mode K?" or "Why are higher and higher frequencies used where I can't just buy equipment?" An historical overview such as the one given in Chapters 1 through 4 either answers such questions directly or gives the rationale for why things are the way they are. Like Americans (and others) who benefit greatly in the present from the efforts and sacrifices of those who came before, Amateur satellite operators today benefit greatly from over thirty years of foundational work, not just in satellite hardware, but in regulatory matters (like the very existence of a Radio Amateur Satellite Service with its own frequency sub-allocations) and on other fronts as well. Anyone who takes satellites seriously enough to get on the air owes it to themselves and to the movement to go over this history.

In Chapter 4, "1980 Into the Future," the history begins to wind through the present and the near future. At this point, Davidoff puts in a rather lengthy discussion of and lobbies for the Phase IV, Geosynchronous program. Two revealing features of the Amateur satellite program are highlighted by this inclusion. First, the service is quite vital and is always changing flavor as key volunteers go through various phases of their activity as decision makers, project participants, and publication authors. The dreams and goals are not always unified and coherent across AMSAT at any given time, particularly in times of transition. Second, and similarly, Phase IV was shelved by AMSAT-NA within just a few months if not weeks of the publication of this edition making most of the Phase IV information obsolete except as a report on half a decade of the studies and preparatory work that was done. At the rate things are going, the *Satellite Experimenter's Handbook* will be in its 3rd or 4th Edition before Phase IV or something like it is sparked off once again.

The section starting with Chapter 5, "Getting Started" contains the introductory information you will need to get started establishing a satellite station. Everything is laid out explicitly in excellent detail, reducing the chances for misunderstandings and bad assumptions by beginners. Statements like, "If you've never operated packet and you want to operate satellite packet, you should first gain some experience operating terrestrial packet on 2 meters." is good advice, and applies to all satellite modes. You'll notice that the emphasis here is on solving the problems of establishing communications, not communicating itself (i.e., what to say once you're on). This again indicates that Amateur satellite communication is still developmental and experimental. An explanation of why Mode A is sometimes flaky during sunspot highs is enlightening. The chapter ends with four case studies describing how Hams from four different backgrounds can find their way into the ranks of active satellite operators. These are fun to read, you'll certainly find yourself and most of your Ham friends among these personalities.

Chapter 6, "Tracking Basics" is the first of several that deals with satellite tracking. It deals mainly with *OSCARLOCATOR* and other similar manual, graphic devices, though it touches on computer programs toward the end. With the prevalence of computers in ham shacks these days, particularly Amateur satellite ham shacks, the quantity of information in this chapter may be a little high. In fact, many of the examples deal with satellites (like AO-8) which were in use when manual tracking methods were in their heyday but which are now long gone. You be the judge, if you really must build some sort of *OSCARLOCATOR*, all the information, references, and sources are right there.

If there is one area where all Hams think they are experts, and few really are, it is antennas. But, I learned, or had clarified, several important concepts about antennas while reading Chapter 7, "Antenna Basics." If everyone thoroughly understood the ma-

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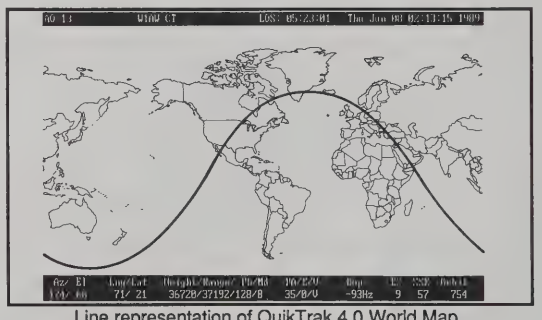

Line representation of QuikTrak 4.0 World Map

QuikTrak 4.0

Whether you want to identify the next time Oscar 13 will provide communications between two cities or if you just want to know the next time you can visually sight the Soviet space station MIR, QuikTrak will let you plug in the latest Keplerian elements for up to 100 satellites using a new full screen editor. QuikTrak also supports autotracking. *Hardware requirements*, IBM PC, AT, PS/2, or clone with a minimum 512K memory. CGA or EGA graphics required. Numeric coprocessor not required but recommended.

InstantTrack 1.0

For those concerned with greater speed and capability, InstantTrack offers all of QuikTrak's features plus instant visibility for your "favorite" satellites before you issue the first keystroke. More than 200 satellites and 1754 cities are on the menu and will be in full-color high-resolution EGA or VGA modes. *Hardware requirements:* IBM PC, AT, PS2 or clone with at least 512K memory. EGA or VGA graphics required. Numeric coprocessor not required but recommended. Mouse not required but can be used on the map screens.

These are only a few of the features of QuikTrak and InstantTrack. The figures below reflect suggested donations to defray production expenses and benefit AMSAT's non-profit, educational activities.

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terial presented here, there would be much less confusion on issues like: "Why is it expeditious but not essential to use circular polarization on AO-13," and "Why is it not necessarily best to use circular polarization on other satellites in other circumstances," and perhaps most important, "What are the differences between transmitting and receiving criteria for antennas?" If you can correctly answer this plus the bonus question, "Why do I still hear signals from AO-13 when I've switched to left hand circular polarization, though they have more spin modulation?" you might be able to safely skip this chapter, however, I would still scan over it to make sure I wasn't forgetting something important before I made any decisions about antennas at my station.

Chapter 8, "Practical Space-Communication Antennas," carries the theory from Chapter 7 into several practical, field proven examples of antennas useful in satellite work. Again, coverage of the topic is very thorough and includes extensive references for further research or investigation. Probably the most valuable part is the good, solid advice on tradeoffs between various antenna systems in various applications. Examples range from extremely simple to rather complex; from tried and true designs to ideas and suggestions for further work by the "real" experimenters out there.

Chapter 9, "Receiving and Transmitting," and Chapter 10, "Operating Notes" get into the details of the radios to be used and how to use them. One interesting but frustrating phenomenon that AMSAT deals with is that satellite operators, both beginners and more experienced ones, seem to grind up a lot of time and energy resolving a lot of the same problems that have already been solved before, like deciding whether or not to use mast mounted pre-amps (or pre-amps at all), how and whether to adapt existing equipment for higher frequency operation in satellite bands, or whether to tune uplink or downlink frequency when spotting on a linear transponder (which, by the way, is a trick question, the rule of thumb is to tune the highest frequency, whichever it is). As with antennas, an excellent use of this book for anyone setting up or improving a satellite station is to think about what you want to do, explore the options that become obvious in thinking and talking about your ideas, then, with the burning issues in mind, review these chapters for good, solid advice and well referenced information. Examples range from pre-amp circuit board designs up to entire station block diagrams, from how to operate a linear transponder to how to contact an RS-Robot. Chapter 9 is particularly good for those working on non-appliance stations. Chapter 10 also has miscellaneous operational information like "Contest Policy" and "435 MHz Transmitting Restrictions." As always, the book provides excellent references and background reading.

Unfortunately, operation is another area where the fast paced, developmental nature of the whole Amateur satellite movement leaves a book with an editorial lead time of several months behind all too quickly. Substantial information about PACSAT file server utilization (such as are used on AO-16, LO-19, and UO-14) is completely missing since the *Handbook* came out at nearly the same time that these server operations began in earnest on the three new PACSATs late in 1990. The information about the FO-20 BBS is still good. If you are interested in setting up a PACSAT station, the *Satellite Experimenter's Handbook* will get you started with radios and some information on 1200 baud PSK modems, but for a discussion of PACSAT software, 9600 baud, and the latest on other hardware, you should obtain the new *Microsat User's Guide* which just became available from AMSAT-NA this Spring.

Chapter 11, "Satellite Orbits," begins a cycle of chapters "For the Advanced Enthusiast." If you're really interested in the physics and mathematics of satellite trajectories and want to write your own computer program for tracking, there is enough information in this chapter to support the work. (I wouldn't recommend writing a tracking program, however, except for self education, or in support of a system for which a program is not already available from AMSAT. Check with AMSAT-NA Headquarters first.) The best general use of this material is to learn or review the various orbital parameters (in standard Keplerian element usage) and their meanings and interrelationships. It stops short (as it should) of a discussion of exotic effects like the luni-solar perturbations which may well spell the early demise of AO-13. Chapter 12, "Tracking Topics" appears to be a catch-all for material not included in Chapters 7 or 11. "How to build and use an OSCARLOCATOR for Phase III" (certainly an advanced topic compared to the simplicity of the Phase II versions!) seems to be the main drift.

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Closing out the set of chapters of interest to ground station builders and users, Chapter 13, "Satellite Radio Links" offers not only an in depth discussion of Doppler shift in its various manifestations but also covers special subjects such as spin modulation, Faraday rotation, and unusual phenomena. Every Radio Amateur (not just satellite operators) should read the "Frequency Selection" section beginning on page 13-9. It covers in depth legal, technical, political, visionary, and sensible issues concerning Amateur frequency management and sharing.

Non-Amateur "Weather, TV, and Other Satellites" and Amateur-grade (read: "cost") ground equipment for receiving them is the subject of Chapter 14. The *Satellite Experimenter's Handbook* is not intended to be the exhaustive reference in this area as well as the Amateur satellite field, but, again, the information is a good introduction and is copiously referenced.

The *Handbook* ends with two chapters on the Amateur satellites themselves. Chapter 15, "Satellite Systems" gives a good overview of existing and potentially useful satellite systems and technologies. I was amazed at the engineering excellence that has been achieved by volunteer Amateur Radio operators in their satellite programs and the visionary approach to low-cost space technology apparent throughout this section. (I was also amazed at the sheer quantity of work that has been done on an unpaid but certainly not unprofessional basis over the years.)

Virtually all Amateur satellite users at one time or another aspire to be involved in actually building a satellite. One other section of this book that all radio satellite Amateurs and members of any kind of volunteer organization should have as required reading is Chapter 16, "So You Want to Build a Satellite." Davidoff has a grasp of the organizational and personnel problems involved in an effort of this type that can only have come from personal experience as both a volunteer and a volunteer manager, and from close association with others in those roles. When you see the (incomplete) list of 19 major activities involved in satellite construction, don't just skip to the soldering, drilling, and bolting parts thinking that they are the only really important ones. AMSAT is very tight with its approach to volunteers and to technological problems, it has to be to accomplish anything at all on very limited volunteer time and even more limited financial and material resources. The categories listed here are some of those that have panned out over many years and many projects as the absolutely essential ones.

The following, representative statement about estimating the personal price of volunteering for an AMSAT task is right on the mark and should be taken at face value:

"Frankly, no matter how thorough you think your estimates [of time and effort that a task will take] are, you'll probably grossly underestimate the real effort needed. Psychologically this might be a good thing: If we knew what we were really committing ourselves to, far fewer might volunteer."

Considering the amount of research and writing that went into the *Satellite Experimenter's Handbook*, the author might well be talking about the book itself with this statement. Once you've seen a copy, I think you'll agree with me that it is one indispensable ingredient of a successful Amateur satellite program.

The work concludes with five Appendices, a Glossary and an Index:

*Appendix A: Radio Amateur Satellite History: Dates and Frequencies
Appendix B: Spacecraft Profiles
Appendix C: Tracking Data and Overlays
*Appendix D: Computer Programs
Appendix E: Conversion Factors, Constants and Derived Quantities
Appendix F: FCC Rules and Regulations Governing the Amateur-Satellite Service

* *indicates an Appendix that is new with the 2nd Edition.*

Appendix B is very complete. For any more information on a particular satellite than is given here, you will need to refer to a specialized publication about specific satellites or specific sub-topics like telemetry. I found Appendix A useful just today. When I heard that AO-10 had been heard in Mode L, it was necessary to refer to an historical frequency list to figure out where to listen. Since the loss of onboard computer control of AO-10 in 1986, it was thought that Mode L would never be available again, so modern frequency guides don't list its beacons or transponders.

I highly recommend the *Satellite Experimenter's Handbook*, 2nd Edition to you. This book belongs within arm's reach of any Amateur satellite user's operating position or workbench. If you already have the 1st Edition, you need to upgrade to the 2nd as soon as possible, before your next need to refer to it. That's where it will be in my shack, just as soon as I finish re-reviewing some of the material on microwave techniques!

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Part I

Minutes by Peter Guelzow, DB2OS
AMSAT-DL Journal, Nr.2/18, June/August 1991

Translated by Don Moe, DJØHC/KE6MN

As in the previous year, AMSAT-DL again invited a large group of experimenters and specialists to attend the second international P3D meeting in Marburg. Over 30 guests from nearly all continents accepted this invitation.

The goal of the four-day meeting was to make decisions on fundamental aspects of the P3D satellite, as well as to determine the preliminary features of the various subsystems, so that the experimenters could begin designing their circuits and building their experiments.

Day 1: Monday, May 6, 1991

At the start of the first session, Karl Meinzer, DJ4ZC, outlined the procedures and the subjects for the following days as well as reviewed the action list from the previous meeting. Several participants were prepared to make various presentations during the upcoming sessions.

Launch Configuration

Karl Meinzer then reported on the current status of P3D, in particular regarding the launch opportunity aboard one of the first two test flights (501 or 502) of the new powerful ARIANE-5 rocket in March and October, 1995. Unfortunately, ESA has delayed the decision about the launch configuration even though this had been promised by early March of this year. The decision is now expected in June. A major uncertainty is the position at which the P3D satellite will be mounted in the APEX payload structure in the upper stage of the rocket. ESA's CLUSTER project is practically the only serious competition to the P3D project.

Hanspeter Kuhlen, DK1YQ, provided an extensive status report about the CLUSTER project. Originally the CLUSTER satellites were planned for an ARIANE-4 rocket, but due to financial and other reasons the decision was revised. The probability that these satellites will fly aboard one of the first test launches for the ARIANE-5 is quite high, according to Hanspeter. The five satellites may also be split up between the two test flights. The total launch mass for the CLUSTER satellites is between 2 and 3 tons. Since they are intended for an orbit with 90° inclination, an apogee of 20*RE and a perigee of 2*RE, the rocket might not launch into the normal GTO orbit. *Editor's Note: RE = Radius of the earth.* This alternative orbit would also be satisfactory as the initial orbit for P3D.

The delay in ESA's decision has put AMSAT in a rather difficult situation since essential aspects of the P3D satellite depend upon it. For example, if due to CLUSTER, P3D is not at the top but lower in the composite structure, additional complications in the design of our satellite will result. In this case, a ring structure would be necessary instead of the cube-shaped box design with two solar paddles, in order to carry at least two CLUSTER satellites. From the viewpoint of AMSAT, this would be a very unsatisfactory arrangement. The design of the P3D structure would then have to accommodate an additional mass of 2.5 tons. P3D would also have to be equipped with correspondingly sturdy interface fittings. This would in turn have repercussions on the weight of our own satellite, the thermal design, the configuration of the solar panels, the antenna design, etc., so that additional costs would ensue for the P3D project. The uncertainty whether P3D will have a ring or box structure affected this experimenters' meeting significantly since many detail decisions had to be postponed until a subsequent meeting.

Karl Meinzer emphasized in the subsequent discussion that contrary to established practice, ESA has given CLUSTER a commitment, even though its financing has still not been secured. This presumably is the reason for the delay and the lack of information. In contrast, the financing of the P3D satellite is already assured, as will be explained later.

ESA is currently not in any position to discuss the launch configuration. Since the prescribed deadlines have not been kept, the planning for the P3D project is now significantly affected. Approximately 20% of the time has already passed and we urgently need to determine which activities can be initiated without knowing the exact launch information such as the satellite structure. The expectation at this time is that the final configuration will indeed be the ring structure. Karl Meinzer emphasized that we have to wait for a decision by ESA and only then can we decide between the box or ring structure.

Hanspeter Kuhlen expressed the opinion that we might also consider launching P3D with an ARIANE-4. Due to the resulting configuration change in the boosters, additional costs of around $10 Million would be incurred, so that this is not a viable alternative. It might be useful to increase the attention paid to the P3D project in world-wide publications and thus increase the pressure on ESA to make a favorable decision.

Launch opportunities on other rockets are virtually nonexistent at this time. Jan King, W3GEY, reported that currently in the USA there are no inexpensive fly-along possibilities for a P3D satellite. After the

The group shot at the P3D Meeting, May 1991. (W4PUJ photo)

A room full of P3D design participants. (W4PUJ photo)

recent failures of various rocket systems, prospects for a launch are nil.

Graham Ratcliff, VK5AGR, had previously mentioned the chances of launching aboard a Chinese rocket in cooperation with the Australian government. In the meantime, the decision has been made there to build a VK-SAT based on the American Microsat design and this would be a purely national project. Unfortunately no funds to support the construction of a larger international satellite are available at this time.

Mikiyasu Nakayama, JR1SWB, reported on the difficulty of launching with a Japanese H2 rocket. A free flight would scarcely be a problem, but unfortunately the security procedures are extremely stringent. The P3D apogee motor with its highly explosive fuel, such as was used in AMSAT-OSCAR 10 and 13, would be the main hindrance. Mikiyasu Nakayama was asked to confirm whether a launch with the H2 rocket would be possible if the harmless 100mN plasma thruster from Professor Messerschmitt at the University of Stuttgart were to be used instead of the 400N liquid fuel motor.

Financing

Following the discussion about the ESA politics, Karl Meinzer described the current financial status of the AMSAT Phase-3D satellite.

AMSAT-DL is obtaining 900,000 DM in support from the German Federal Ministry for Research and Technology (BMFT) thanks to the concept of the LEILA transponder. The German Amateur Radio Club (DARC) will provide 900,000 DM over a six year period in 150,000 DM installments. An additional 300,000 DM are coming from private donations from BRAMSAT, AMSAT-Spain, AMSAT-UK and others. Mikiyasu Nakayama reported that the Japanese Amateur Radio League (JARL) would like to promote future Amateur Radio satellite projects quite significantly and would probably provide between 500,000 and 1 Million $US. Appropriate negotiations must be initiated by AMSAT-DL. Doug Loughmiller, KO5I, is confident that AMSAT-NA and the ARRL can contribute approximately 500,000 $US over a period of 6 years to cover the launch costs.

Freddy de Guchteneire, ON6UG, will prepare an IARU recommendation in order to promote the P3D satellite since it is truly a very international project. The IARU itself cannot afford a financial contribution, but rather has to leave that up to the national member organizations.

Furthermore an oversight panel will be formed consisting of the various associations and groups which provide the major financial and material contributions to the project. Members would be the DARC, AMSAT-NA, BMFT (represented by AMSAT-DL) and AMSAT-DL itself. The number of votes in this panel would be in relation to the contributions. This panel would decide in particular about the operation of the satellite in the operational phase, such as the activation periods for specific experiments and the transponder schedules. *Note: at the subsequent AMSAT-DL annual members meeting on May 11, 1991, the establishment of this panel was unanimously approved by the members.*

Satellite structure

Since no final structure could yet be determined for P3D, only the following basic details could be agreed upon. The height of the satellite will be nearly 650 mm, plus 186 mm for the attachment fittings, resulting in a total height of 1 m between the two separation planes in the case of the ring structure. The diameter of the ring or the diagonal of the cube structure would be 3.19 m. From this base line, the question arises whether the ring structure could be stabilized in three axes and what consequences this would have on thermal control in particular. The latter is probably the main problem. Dick Jansson, WD4FAB, will undertake the corresponding analyses.

Stabilization

In a brief presentation, Karl-Max Wagner, DB8CO, described his ideas on a fluid-based 3-axis stabilization technique (Liquid Fluid Momentum Control). As it turned out, essential problem areas had already been discussed at the first P3D meeting. The most important aspects of such a stabilization system are the amount of storable momentum, total mass and power consumption. He was asked to do further work on his ideas until the requirements are fulfilled.

Thermal Design Parameters

Dick Jansson presented the results from

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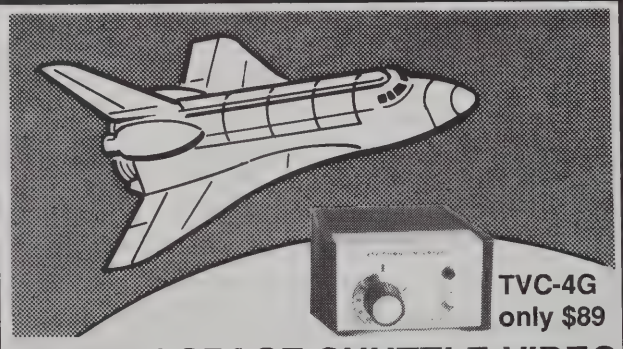

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P.C. ELECTRONICS

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Tom (W6ORG)
Maryann (WB6YSS)

his computations on the temperature management of the P3D satellite and provided extensive explanations.

Basic Assumption:

Design	"Two Cubic Meter"
Surface Area	8.93 m^2
PWR Dissipation	500 Watts (max.)
Proj. Solar Area	135.4 mW/cm^2
Incident Solar Pwr	2.85 kW (2 side proj. area)

Normalized Power Values:

Electrical Power Dissipation	5.6 mW/cm^2
Absorbed Solar Dissipation	2.9 mW/cm^2 a > 0.09
Space Radiation Cooling	30.9 mW/cm^2 e = 0.85, T=10°C
	26.8 mW/cm^2 e = 0.85, T = 0°C

The computations indicate that cooling would be no problem, and even a thermal blanket may be required to prevent undercooling. The main problem will be conducting the warmth between zones of intense heating, such as from the sun and the heat dissipation of the transponders, and the zones in shadow where extreme cooling occurs. Possibly heat pipes would be needed in order to transfer effectively the power dissipated by the high power transponders. Dick Jansson came to the fundamental conclusion that the thermal design of the cube structure with the two solar panels is no problem.

In the case of the ring structure, the surface area is very large and thermal blankets would be needed for thermal control and to prevent the side of the satellite in the shadow from cooling excessively. On the side facing the sun, the solar panels will heat up significantly and thus must be cooled by numerous U-shaped heat pipes. Karl Meinzer suggested the option of mounting solar cells along with orbit solar reflectors (OSR) in an alternating pattern. The spacing and width of the two zones needed to regulate the temperature could be calculated. The regions directly illuminated vertically by the sun would normally become quite hot, whereas the temperature of the neighboring cells reduces with the cosine of the angle and thus smaller OSR regions would be needed. Of course when heat pipes are installed, the entire area would be used for maximum power generation, although at a rather high price.

If the solar panels were mounted so that they could dissipate heat on both sides, their temperature would only rise to 36.6 C. This could be achieved mechanically by allowing the 1 m high solar panels to extend beyond the upper and lower sides of the 650 mm high structure. Unfortunately this idea is not practical since a symmetrical structure is necessary during the launch phase prior to transition to three-axis stabilization. Also the structures of the other payloads could interfere.

In conjunction with other mechanical aspects, Dick Jansson suggested constructing the structure adapter from carbon fibers. This would have the same stability as an adapter made from aluminum but with less weight and would be easier to fabricate. He was asked to investigate this possibility further.

Following the midday break, Dick Jansson continued his presentation on the cubical structure and showed how various different solar cells could be mechanically arranged. One configuration results in a power generation of 265 W at a bus voltage of 36 V. He then went on to describe how a rotating transformer could be a possible solution to the problem of transferring power from the rotatable solar panels to the satellite. This would involve relocating some of the elements from the battery charge regulator (BCR).

The location of the fuel tanks and the mounting of the motor were also brought up. In the case of the 400 N MBB motor, at least three fuel tanks are necessary. Karl

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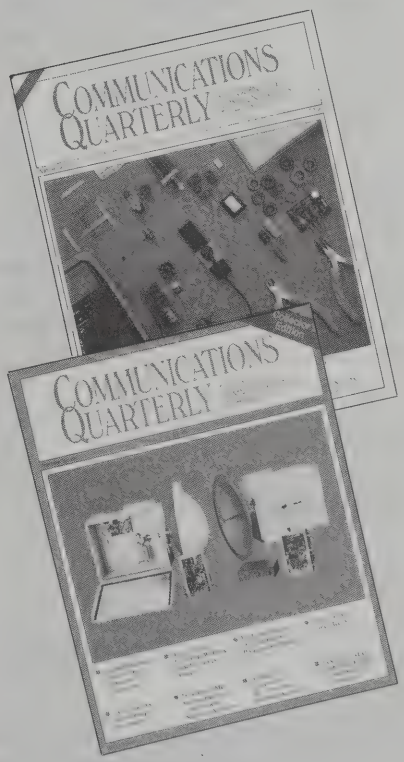

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Meinzer mentioned the option of mounting the motor off center rather than in the center of the satellite adapter. At the expected spin rate of 5 to 10 rpm, the resulting reduction in efficiency due to nutation would be practically negligible. The main problem is feeding the fuel to the motor and this requires additional analysis.

A brief discussion ensued from the suggestion that a standardized experimental payload configuration be implemented. This system would only have a single interface to the outside, but internally its own bus system for exchanging data between the various experiment modules which would be in a stack configuration. The advantage would be that the experiments could be assembled and tested independently of the rest of the satellite.

Dick Jansson also reported on a solar panel design in which the substrate carrier consists of a honeycomb structure having extremely high mechanical stability and no resonances below 16 Hz. Additional suggestions involved the mechanical design of the attachment flange and the vibration table adapter. In conclusion, Dick Jansson outlined a ring configuration with two extendable solar panels and the fuel tanks mounted in the interior of the adapter. He will work on these suggestions further and also the implications of the launch variations on the satellite structure.

Propulsion

In order to reach the desired orbit, the P3D satellite requires its own motor, as was the case for OSCAR 10 and 13. The current options are another 400 N motor from MBB or an electrical plasma thruster developed under the direction of Professor Messerschmitt at the University of Stuttgart. To provide a thrust of approximately 100 mN (milli-Newtons), it needs 300 W of power and consumes 30 mg of ammonia per second. At an ISP of 4000 to 6000 m/s, it would take nearly a year to achieve the final orbit. This thruster is available, although AMSAT would have to build a power conditioner in exchange. Karl Meinzer considers a combination of both motors desirable. The 400 N motor would carry out the larger orbital maneuvers, and the plasma thruster could be used periodically to make small corrections and keep P3D in an optimal orbit. This combination would also offer an additional margin of safety in case of problems. An analysis is necessary to determine the best mounting location for the plasma thruster to avoid having to constantly reorient the satellite.

Attitude Sensing and Control

Jan King reported on his efforts to find suitable navigation sensors. Space Sciences Corporation (SSC) develops Sun and Earth sensors as well as star trackers mainly for the small satellite market. However, their Earth sensors are equipped with mechanical moving parts, such as mirrors. SSC might be interested in cooperation and an appropriate proposal should be made. Karl Meinzer noted that no Earth sensors would be necessary if a reliable star tracker is used. However, the entire useful lifetime of P3D would depend on the reliability of a CCD star tracker and to-date there are no long-term data available about how CCD sensors hold up in a radiation environment. Jan was asked to remain in contact with SSC on the star sensor. Karl-Max Wagner suggested using a normal tube video camera instead of the CCD camera. Since it would be switched on at most once per week, the lifetime would probably be no problem.

Matjaz Vidmar, YT3MV, suggested using an X-band receiver as an Earth sensor. Karl Meinzer and Bob McGwier, N4HY, will analyze whether an interferometer can be used for the position determination, whereby an accuracy of 1 degree would suffice. A 22 GHz radiometer could possibly be obtained for this purpose.

Another aspect discussed was the required accuracy of a solid state gyro. Gordon Hardman, ZS1FE, and Jan King reported on an inexpensive gyro designed around the "wine glass" technique, although the stability is only 3 degrees per hour. According to Karl Meinzer, a drift no worse than 3 degrees per day is needed. A sensible combination would be to use the less accurate "wine glass" gyro for short term navigation and a very precise Earth sensor for long term navigation. Even building a fiber optic gyro would be feasible, although radiation resistant fiber material would have to be used. According to Mikiyasu Nakayama, a fiber optic gyro from Hitachi in Japan has a drift of nearly 10 degrees per hour.

At 17:30 Karl Meinzer closed the session for the first day.

Part II of this article will appear in the next issue of *The AMSAT Journal*. ■

AMSAT News

The 1991 AMSAT Annual Meeting and Symposium, Los Angeles Airport Holiday Inn, November 8, 9 and 10

Mark your calendars and make reservations for this year's AMSAT-NA annual meeting and symposium, hosted by the Jet Propulsion Laboratory Amateur Radio Club, the World Space Foundation and Los Angeles area AMSAT members. The meeting and symposium will be held at the Los Angeles Airport Holiday Inn, located only five minutes from the airport, and central to many of the interesting and exciting attractions Los Angeles has to offer.

The event begins on Friday afternoon (Nov 8th) with registration in AMSAT's hospitality suite at the hotel. Friday's activities will include the presentation of selected papers, informal get-togethers, and family activities such as a trip to the famous Griffith Observatory. Friday also offers an excellent opportunity to meet with friends and survey the year's accomplishments over dinner or around the bar.

Saturday is symposium day with the presentation of technical and operational papers beginning at 8:00 AM. These multimedia lectures will include topics such as OSCAR 13's orbital status, development and progress of the Phase IIID bird, the Microsats, SAREX projects, AMSAT educational projects and lots more! These sessions will continue all day Saturday until about 5:30 pm. Following the day's talks, it's off to the famous pre-banquet attitude adjustment session (6:30 to 7:15 pm). The banquet will feature an excellent choice of fare complemented by exciting keynote speakers, the president's report, current status of AMSAT-NA and other topics. Valuable prizes and awards of appreciation are also presented at the banquet.

Sunday's activities will include more sessions, formal and informal breakfast meetings, satellite equipment displays, a working OSCAR-13 and Microsat station, and lots of planned family activities. Depending on interest, these might include a trip to Disneyland, Pasadena's Jet Propulsion Lab, the Museum of Science and Industry and its' giant screen IMAX theater, and the Griffith Observatory with its' many space and science exhibits, planetarium, solar telescope, etc.

The meeting, symposium, and banquet will all be held at the Los Angeles Airport Holiday Inn, located on Century and La Cienega Blvd in Los Angeles. A special rate of $55.00 per night for a single room has been negotiated for all attendees. This rate includes a free buffet breakfast! Please register with the hotel early by calling 1-800-465-4329 and ask for the special AMSAT rate. Some members will fly in on Thursday and leave Monday or Tuesday so you might want to consider an extended stay as well. There will be plenty of activities.

The AMSAT registration fee has not been finalized, but it is expected to be between $15.00 and $18.00 for AMSAT members registering in advance. Look in September's *AMSAT Journal* for an official registration form as well as a comprehen-

sive schedule on all symposium activities and available family activities. Any questions about this event can be answered by the symposium committee c/o Talisman, 7217 Melrose Ave, Los Angeles, CA 90046. They can also be reached by telephone at 213-937-7942 11am to 6pm Pacific time. Stay tuned to AMSAT nets and publications for more details. Hope to see you all in Los Angeles!

UoSAT Data Capture and Display program for the Commodore C-64 announced

John A. Magliacane, KD2BD, has allowed AMSAT-NA to distribute his latest software development for the Commodore C-64; UoSAT Data Capture and Display Program. This program will enable reception of digital communications from the UoSAT-1 (OSCAR-9 type) and UoSAT-2 (OSCAR 11 type) satellites. For those who prefer the low cost approach to amateur satelliting, this program is a must!

The program will decode digital data including spacecraft telemetry data, Whole Orbit Data (WOD) frames, On-board Computer (OBC) status, plain text news bulletins, and DCE (Digital Communications Experiment) message frames. It was written in hand-assembled 6510 machine language which translates to a very high speed execution time. It features a 47,102 byte memory storage area, and edits all received data through a software filter in order to prevent any display or storage of invalid ASCII characters.

The UoSAT-1 and UoSAT-2 type satellites use phase synchronous AFSK 1200 Hz and 2400 Hz tones to deliver the digital data. These tones are close enough to the Bell 202 standard that a surplus Bell 202 modem could be used for demodulation. Circuits would have to be developed to convert the +/- 12 volt RS232 signals to the Commodore TTL RS232C levels.

John has provided us with a schematic of a low-cost demodulator which can be built with a few evenings of work. The only component of this circuit which is not "readily" available is the demodulator chip, the XR2211. AMSAT-NA has agreed to buy these chips in bulk quantity and is offering these chips as an option to the program for only $5.00 extra.

The UoSAT Data Capture and Display Program loads up and is ready to go from the very start. Capturing the digital data to the memory area is only a function key away. The color enhanced information assists the user in monitoring progress of capture mode. The memory contents may also be viewed through the use of a function key. The memory area can be cleared at any time, again, via a function key. Just in case you get confused by all of the function keys, the documentation comes with a nice function key overlay designed for this program. The function keys also allow for saving of captured data in memory to a file on disk, loading a file from disk to memory of previously captured data, and printing of captured data in memory. The user can even get a listing of the disk directory from within the program. Because it was written in machine language, it is loaded under ROM, so it does not interfere with things once you exit the program and run in BASIC. To access the program once again, all you have to do is enter a simple POKE command from BASIC. Not the least of the program's powers is that it also does a translation of the DCE form of the UoSAT transmissions. A complete description of how the program handles the DCE communications format is contained in the documentation.

The subject of documentation of a program is highly under-rated. In this case, it is one of the best qualities of the program. It is obvious that John has taken a great deal of time and trouble to properly document this program. It is not a burden to read, contained in less than ten pages.

We at AMSAT-NA hope you will enjoy this program. And we would like to formally thank John A. Maglicane, KD2BD, for providing the Amateur Satellite community with another fantastic piece of software. It is available through the AMSAT Software Exchange. ■

Software Pirates

(from page 3)

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Satellite Orbital Elements July 9, 1991

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AO-10
1 14129U 83 58  B 91180.83822331 -.00000093  00000-0  99998-4 0  6820
2 14129  25.8249 138.0188 6036857 254.6320  34.6191  2.05884160 32503
UO-11
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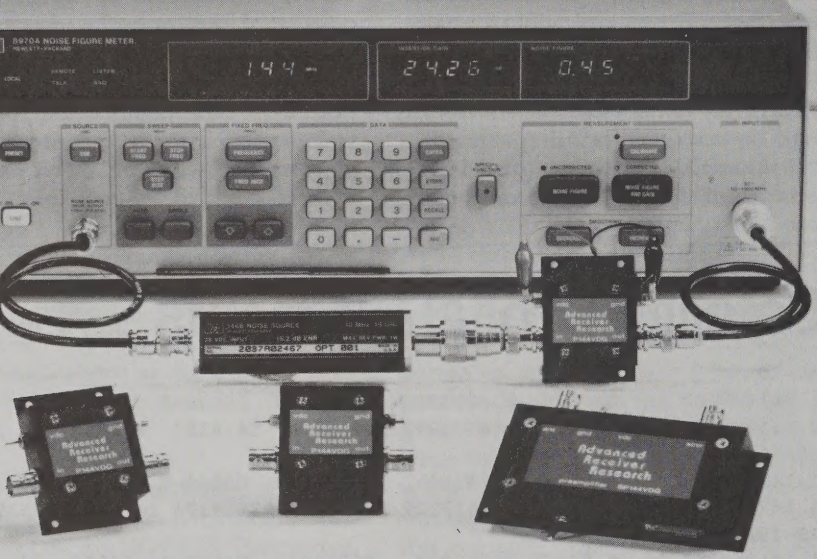

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P50VDG	50-54	<0.5	24	+12	GaAsFET	$79.95
P144VD	144-148	<1.5	15	0	DGFET	$29.95
P144VDA	144-148	<1.0	15	0	DGFET	$37.95
P144VDG	144-148	<0.5	24	+12	GaAsFET	$79.95
P220VD	220-225	<1.8	15	0	DGFET	$29.95
P220VDA	220-225	<1.2	15	0	DGFET	$37.95
P220VDG	220-225	<0.5	20	+12	GaAsFET	$79.95
P432VD	420-450	<1.8	15	−20	Bipolar	$32.95
P432VDA	420-450	<1.1	17	−20	Bipolar	$49.95
P432VDG	420-450	<0.5	16	+12	GaAsFET	$79.95
Inline (rf switched)						
SP28VD	28-30	<1.2	15	0	DGFET	$59.95
SP50VD	50-54	<1.4	15	0	DGFET	$59.95
SP50VDG	50-54	<0.55	24	+12	GaAsFET	$109.95
SP144VD	144-148	<1.6	15	0	DGFET	$59.95
SP144VDA	144-148	<1.1	15	0	DGFET	$67.95
SP144VDG	144-148	<0.55	24	+12	GaAsFET	$109.95
SP220VD	220-225	<1.9	15	0	DGFET	$59.95
SP220VDA	220-225	<1.3	15	0	DGFET	$67.95
SP220VDG	220-225	<0.55	20	+12	GaAsFET	$109.95
SP432VD	420-450	<1.9	15	−20	Bipolar	$62.95
SP432VDA	420-450	<1.2	17	−20	Bipolar	$79.95
SP432VDG	420-450	<0.55	16	+12	GaAsFET	$109.95

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The Shape of Bits to Come

(from page 17)

ably within 1 dB of the theoretical limit. [20 Log (1 - 8/100)].

It is flying on RUDAK-2/AO-21 so AMSAT experimenters (i.e. YOU) can evaluate the effectiveness of high speed PSK with or without coding [3] from the associated on-board Harris RTX2000 RISC processor. This will help determine what is practical and realistic for Amateur spacecraft and other digital links of the future.

The G3RUH 9600 baud FM system is not only in daily use by many satellite stations on UO-14, but also hundreds of terrestrial packet radio links world wide. It represents a design that pushes the fastest possible binary data through a basic FM radio. The 9600 bps throughput is astonishing to behold, especially on a full duplex satellite link.

Who will predict that one day even our voice transponder links will be entirely digital. Amateur ISDN? Now there's a challenge!

References

1. Miller, J. R., "9600 baud Packet Radio Modem Design," Proc. 7th ARRL Computer Networking Conference, 1988 Oct, pp. 135-140.

2. Meinzer, K. & Haas W., "RUDAK 2 - The Radio Links," *Amsat-DL Journal* No. 1/17, March 1990 pp. 9-12. (German). English translation in *Oscar News* No. 83, 1990 June, pp. 16-21.

3. Miller, J. R., "Shannon, Coding and the Radio Amateur," *Oscar News* No. 81, 1990 Feb, pp. 11-15.

Graphics Note

The spectral plots in this article were created using an Acorn Archimedes 400 series computer. This RISC based machine is astonishingly fast for the price, performing FFTs in ordinary BASIC at about the same speed as FFTs machine coded on a conventional 6502 micro e.g. C64, BBC B, Atari 800XL etc. Highly recommended. ■

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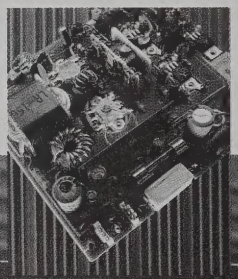
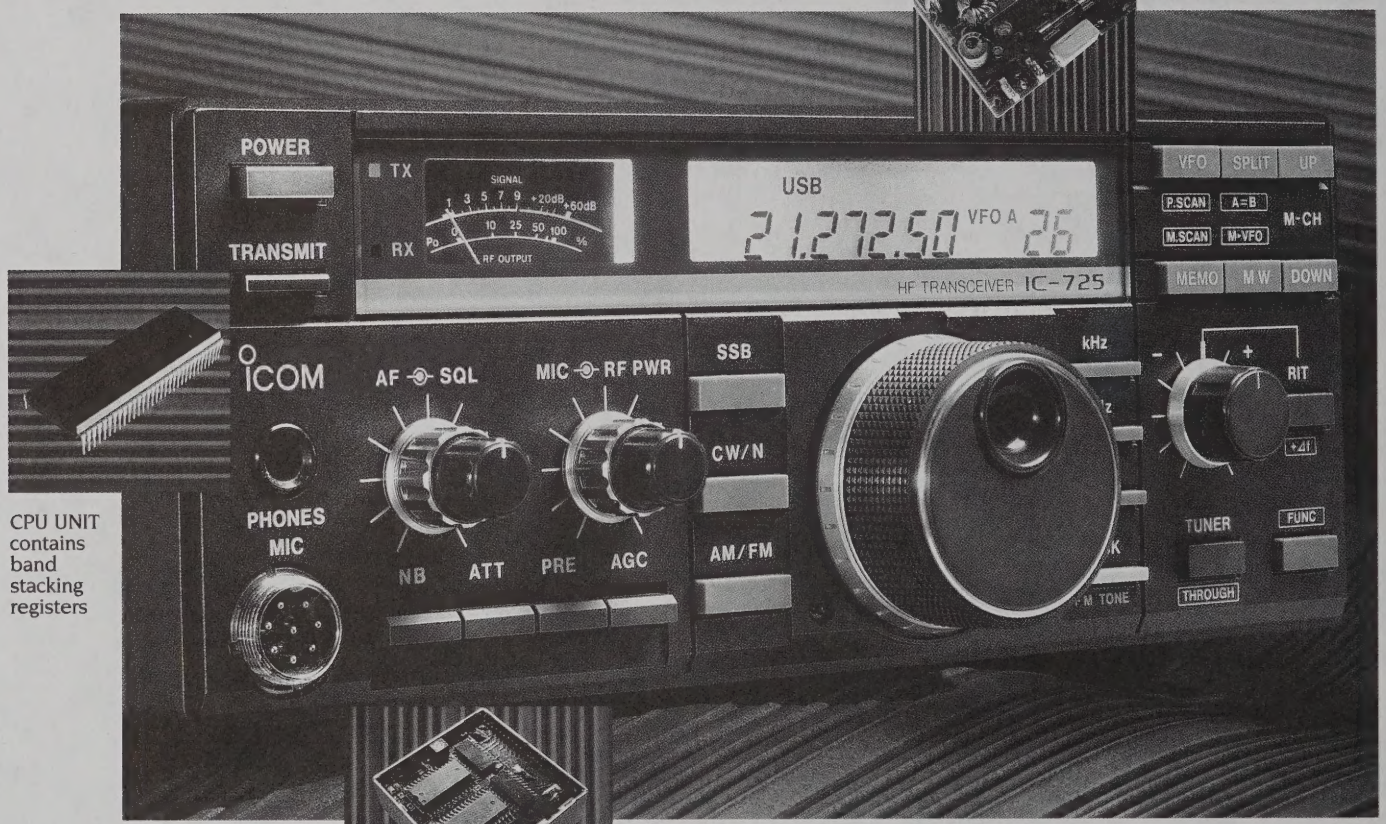
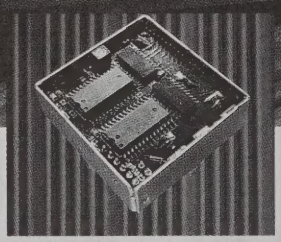


PA UNIT
provides 100%
duty cycle



CPU UNIT
contains
band
stacking
registers



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